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EDITOR'S NOTE

The agreement late last year in the CD to establish an Ad Hoc Committee to negotiate a ban on the production of fissile material has encouraged UNIDIR to dedicate this issue of *Disarmament Forum* to that topic. Included are forward-looking appraisals written by experts on what will be key factors, topics and divisions in the negotiations. Also included in this issue is a completely updated edition of *The Fissile Material Cut-Off Debate: A Bibliographical Survey* (UNIDIR Research Report no. 38), first published in 1996. This is a useful compilation of recent articles in English and French concerning fissile materials.

In addition to this issue of *Disarmament Forum*, UNIDIR has two other forthcoming publications on the topic of fissile materials: *Fissile Material Stocks: Characteristics, Measures and Policy Options*, by William Walker and Frans Berkhout, and *Stocks of Fissile Materials for Weapons Purposes,* by Frans Berkhout. These three publications will be useful tools for those who follow or participate in the negotiations.

Sadly, the fissile material negotiations have been slow off the mark in 1999. The first session of the CD has ended with little movement on this issue. The ongoing disagreement on the most basic items — as evident in the controversy over what to call the treaty — has entrenched many divisions before the actual negotiations have even started. In this vein, we received the following poem venting one anonymous individual’s frustration with disarmament negotiations getting caught up in minutiae.

A Comment on the Comma

The misuse of the humble comma
Lends license to the nuclear bomber

A comma in its proper place
Can serve to save the human race

But have you ever seen a nation
Destroy itself through punctuation

The new UNIDIR research project, The Costs of Disarmament, is getting underway. This year-long project will examine a few key countries as examples and carefully research what their commitments to disarmament treaties mean to them in terms of financial and resource costs. In addition, the project will try to ascertain what each country perceives are the benefits brought to them through their participation in the agreements and whether there is consensus that there is a net gain to the state in question. The aim of the project is to achieve a better understanding of the costs and benefits of disarmament agreements with a view to assisting policy-makers to decide how money is spent on such commitments, which budget lines are best structured to handle such spending and how states could approach this aspect of negotiations in the future.

We have received a lot of positive feedback on the first issue of *Disarmament Forum*. Please feel free to send your comments or suggestions to dforum@unog.ch.

Kerstin Hoffman

Banning the Production of Fissile Material for Nuclear Weapons or other Nuclear Explosive Devices

The 'nuclear age' since 1945 has been dominated by two contrasting trends. One has been the development of nuclear weapons by various countries, primarily by the five nuclear-weapon states (NWS) acknowledged by the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) but also by several other states as well. The other has been the efforts by the international community to secure the elimination of nuclear weapons by those states which have them and the prevention of the spread of nuclear weapons to others. The attainment of these two latter objectives — classically, nuclear disarmament and nuclear non-proliferation — remains vulnerable to broader political and security developments globally and regionally. The 1990s have been schizophrenic in that regard — it has been a decade of both great promise and of vision-shattering disappointment. The great challenge now facing the global community is to regain and realize the promise while overcoming the disappointment.

The renewed effort in recent years to achieve a multilateral treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices is taking place in the above context. While the goal is not a new one — its roots can be traced back to the first annual report of the United Nations Atomic Energy Commission in December 1946 — its definition and the environment within which its attainment has been sought have evolved over the past half-century. In the late 1990s that environment is defined by both history and by current events. While some positive progress has been made, the five NWS continue to possess large inventories of nuclear weapons; the plans and actions of several other states are highly relevant in this respect. Estimates have been advanced that among these states there are enormous stocks of weapons-usable fissile material, that is, 250 metric tons of plutonium and 1,700 metric tons of highly enriched uranium. These facts, and the recently heightened uncertainties triggered by the May 1998 nuclear explosions conducted by India and Pakistan, will dictate the framework for the negotiation of such a treaty.

So where are we in the spring of 1999? The Conference on Disarmament is trying to regain the momentum gained in August 1998 when it decided to negotiate "on the basis of the report of the Special Coordinator (CD/1299, 24 March 1995) and the mandate contained therein, a non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices" (CD/1547, 12 August 1998). While the specific mandate provided in this formulation focuses on the production of such material, the formulation also explicitly provides that no delegation is precluded from raising for consideration certain other issues such as past production (or stocks) as well as the management of such fissile material. So the immediate challenges are to secure agreement on the re-establishment of the Ad Hoc Committee from 1998 and to begin negotiations within an approach responsive to the above considerations. Significant challenges indeed!

Moreover there is no doubt as to the complexity of the negotiation process. Vulnerable throughout to political and security developments external to the Conference on Disarmament, the negotiations will almost immediately begin to address three categories of overlapping issues. First will be so-called 'conceptual parameters' which in addition to the stocks issue will include questions such as the political-legal characterization of prospective states parties and possible moratoria on current production. Fundamental strategic issues such as scope, definitions and verification will need to be confronted. And sooner rather than later structural matters (e.g. governance, verification machinery, financing) will need to be considered. The difficulties to be overcome are almost overwhelming; most delegations anticipate a lengthy and arduous negotiating process.

But it is essential that the Conference devote itself to these negotiations. Following upon the negotiation of the Comprehensive Nuclear Test-Ban Treaty in the mid-1990s, this is the logical next step in the multilateral nuclear disarmament/nuclear non-proliferation process. If momentum is not maintained in this process, then the risk will grow, as in the bilateral nuclear disarmament field of START, that not only will further progress evade us but that we may well begin to fall back from attaining our twin objectives. A viable, credible and effective ban on the production of fissile material for nuclear weapons and other nuclear explosive devices will cap existing stocks, will open the door to reducing and eventually eliminating those stocks, and will add incremental weight to existing nuclear disarmament and nuclear non-proliferation measures. These are outcomes worth pursuing now more than ever.

Ambassador Mark Moher

Permanent Mission of Canada to the United Nations

BACKGROUND

A treaty to ban the production of fissile materials for weapons purposes — highly enriched uranium or separated plutonium — and to place all remaining production of these materials under international safeguards, has been gaining recognition in the past years as the next major nuclear treaty to be negotiated by the multilateral negotiating forum of the Conference on Disarmament (CD). To date, four of the five nuclear-weapons states (NWS) have announced their cessation of fissile material production. However, a universal fissile material treaty will be necessary in order to include all states capable of producing weapon-usable fissile material, to put a legally binding cap on production, and to allow for verification of civilian production in all nuclear-capable states.

There are two broad issues that will complicate negotiations. The first concerns scope: will the treaty be strictly a non-proliferation measure, or will it be linked to disarmament as well? As originally conceived, the treaty would address only future production of fissile material, not existing stocks, hence the name 'Fissile Material Cut-off Treaty.' However, many countries regard such wording as merely a non-proliferation measure and insist that existing military stockpiles be reduced as well. The second issue concerns verification. A verification regime will be necessary to ensure compliance and will likely be applied in a manner similar to IAEA safeguards in non-nuclear-weapon states. How comprehensive such a regime might be will depend on the scope of the treaty and the costs of implementation. While the NWS in particular favour more limited safeguards covering only production and reprocessing facilities, others have called for comprehensive safeguards in order to put all states on equal footing.

Interest in a fissile material treaty dates back to the early years of the nuclear age. In 1946 the United Nations Atomic Energy Commission adopted the Baruch Plan, a proposal calling for international regulation of atomic energy. Eisenhower's "Atoms for Peace" speech in 1953 hinted at a ban on production of fissile materials for weapons purposes. In the following decade, numerous proposals were presented by the Soviet Union and Western countries calling for the cessation of fissile material production and agreements in which fissionable materials would no longer be used for weapons purposes. The Tenth Special Session of the United Nations Devoted to Disarmament (1978) included a proposal by Canada that called for the banning of fissile materials for use in weapons as one step in a process of 'suffocating' nuclear proliferation. In a 1980 document [CD/90] entitled "The Prohibition of the Production of Fissionable Material for Weapons Purposes," Canada and Australia trace the evolution of global thinking on a fissile material treaty, and show that "in one form or another, a proposal to prohibit the production of fissionable material for weapons purposes has been before the multilateral disarmament negotiating body for nearly twenty-five years. At

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various times, concrete suggestions have been advanced by States from all groups, while at other times the proposal has slipped into the background. At no time, however, has the proposal been discarded as either impracticable or unattainable." However, during the Cold War, the proposal stood little chance of reaching the negotiating table, as the two superpowers were reluctant to freeze their stockpiles at a level lower than that of their rival. It was not until December 1993 that the United Nations General Assembly reached a consensus resolution calling for negotiations on a treaty to ban the production of fissile material. The CD, in its 1994 session, appointed Canadian Ambassador Gerald Shannon as a Special Coordinator. Over the course of the next year, Ambassador Shannon consulted with CD members and in March 1995 the CD adopted the 'Shannon Report' agreeing to establish an Ad Hoc Committee to negotiate the treaty. The 'Shannon Mandate' contained within this report is based on the General Assembly resolution of 1993, which directs the Ad Hoc Committee to negotiate "a non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices." But because the CD was unable to reach consensus regarding the mandate of the treaty, the Shannon Report does not preclude any delegation from raising the issues of scope and verification within the Ad Hoc Committee.

The continuing disagreement in the CD regarding linkage to nuclear disarmament prevented the establishment of an Ad Hoc Committee on fissile material negotiations for another three years. In August of 1998, the CD established an Ad Hoc Committee under the leadership of Canadian Ambassador Mark Moher. The committee met only twice before the end of the final session, but it was hoped that it would be re-established early in 1999, and that substantive negotiations would begin this year. As we go to press, agreement on the CD's Programme of Work has yet to be reached. This impasse, centring on nuclear disarmament and the militarization of outer space, has delayed the beginning of negotiations on fissile materials. UNIDIR is not alone in hoping that consensus can be found soon and negotiations begin in the second CD session of 1999.

Rebecca Stevens

A FMCT:
Can We Get from Here to There?

Lewis A. Dunn

First surfaced on the nuclear disarmament agenda in the 1950s, the concept of a cut-off of the production of fissile material for nuclear weapons took on new life in the early 1990s. Hopes were high that negotiations on a Fissile Material Cut-off Treaty (FMCT) would soon begin at the Geneva Conference on Disarmament (CD). This promise collapsed in 1995, when apparent agreement on a mandate to begin negotiations in the CD broke down. Perhaps surprisingly, the May 1998 nuclear tests by India and Pakistan gave renewed impetus to a FMCT and negotiations have now begun at the CD.

Successful negotiation of a FMCT (or cut-off, for short) will require that many technical issues be resolved, from defining what materials a cut-off will cover, to developing specific procedures for verification. But getting from today's negotiations to tomorrow's treaty will demand that the negotiating parties define what is meant by a cut-off. Both more streamlined and more ambitious approaches have been put on the table. In that regard, three especially tough political issues will need to be sorted through. These are:

- differences over the scope of a cut-off verification regime, including especially whether to use that regime as a means to equalize the safeguards burden between the nuclear-weapon states (NWS) and the non-nuclear-weapon states (NNWS) parties to the Nuclear Non-Proliferation Treaty (NPT); [1]
- differences over how cut-off negotiations should handle past production and existing stocks of weapon-usable fissile materials; and not least,
- convincing key countries, including such critical countries as India, Pakistan and Israel as well as the five NWS, that a FMCT is in their political/security interest or, barring that, determining whether a cut-off must be universal from the start.

This paper briefly examines each of these three issues. Its purpose is not to provide definitive answers to them but rather to carry on a debate that already has begun. Its basic message is clear: prospects for successful negotiations will be enhanced by streamlining our objectives and not trying to make a FMCT carry too much of the future nuclear non-proliferation and disarmament agenda. It may also be necessary to trim our commitment to universality as of entry into force, and instead accept the possibility of a more evolutionary process of adherence.

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Cut-off Verification and the Safeguards Burden

Under the NPT, the NNWS have agreed to accept comprehensive safeguards, including extensive routine inspections and other monitoring by the International Atomic Energy Agency (IAEA), on all of their peaceful nuclear activities. By contrast, under the NPT, the NWS are not legally obligated to accept such international safeguards. Led by the United States and the United Kingdom, the five NWS have each made so-called "voluntary offers" to permit the IAEA to conduct inspections of their peaceful nuclear facilities. The scope of these voluntary offers varies considerably, however, in terms of facilities covered. In practice, moreover, the IAEA has only inspected a sampling of the peaceful facilities of NWS.

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In some NNWS, there is considerable sentiment to use a cut-off verification regime as a means to "rectify" this situation and impose a more equal safeguards burden on the NWS. Supporters of this view argue that a cut-off verification regime should be comprehensive in scope and draw extensively on the elements of traditional safeguards under INFCIRC/153. In effect, the regime would be designed not simply to monitor the shutdown of production activities related to nuclear weapons, but to bring under international inspection all non-military nuclear activities in the NWS. It would monitor any residual production of plutonium and highly enriched uranium (HEU), as well as the status of former production plants and also spent fuel.

By contrast, a more streamlined verification approach would concentrate on monitoring declared enrichment and plutonium production facilities, including shutdown facilities. Rather than monitoring the full fuel cycle, it would track any production of plutonium or HEU up to the point that such materials were used for a permitted civilian nuclear purpose. It would rely on challenge inspections to detect undeclared facilities or diversion of materials from declared enrichment or reprocessing facilities producing materials for civilian purposes or non-proscribed military purposes, such as naval reactor fuels.

Proponents of a more comprehensive verification regime argue that it would foster greater transparency among the five NWS, lessen mutual suspicions among them, and enhance wider confidence in their compliance. At root, however, their advocacy of this approach reflects a strong underlying political interest in equalizing the burden of safeguards.

Pursuit of that political interest could well be self-defeating to the goal of realizing a treaty. Extending the scope of a cut-off verification regime to encompass routine inspections of the full peaceful nuclear fuel cycle would most likely increase opposition to such a treaty in key countries such as Israel, India and Pakistan. Indeed, one reason for some Indian officials' past opposition to cut-off negotiations in the CD almost certainly has been concern that a FMCT is the NPT in disguise. Similarly, in some of the NWS, not least China, a more expansive verification regime would likely reinforce Chinese suspicions of on-site inspections and provide that country with a rationale for not agreeing to a formal production ban. Considering the Russian Federation is already financially unable to meet its arms control obligations, the increased costs of a more expansive verification approach would strengthen opposition to the cut-off. Costs also could play heavily in any debate in the United States Senate about ratification of a future FMCT.

In the final analysis, technical as well as political considerations will shape the contours of FMCT verification. Nonetheless, these risks all suggest that prospects for successful negotiations will likely be increased by taking a more narrow rather than a more expansive approach to that verification task.

Existing Stocks and FMCT

Perhaps the most vexing political challenge likely to confront the CD negotiations will be how to handle the question of existing stocks—what, if anything, should be done in a future FMCT on the matter of previously produced stockpiles of plutonium and HEU. Differences on this matter helped block the start of negotiations in 1995 and very different perspectives persist.[2] In differing degrees, each of the five NWS has indicated its belief that the question of existing stocks extends beyond the purview of a FMCT. Several Western countries and some key developed countries, by contrast, have pressed strongly for covering existing stocks of weapon materials in a FMCT, arguing that not to do so would be to leave an important gap. Among the nuclear-capable countries, India and Israel have argued against expanding the scope of a cut-off agreement, while Pakistan has been one of the leading voices for using a cut-off treaty at least to increase transparency for existing stockpiles of weapon-usable plutonium and HEU.

Given these contending positions, any progress on the issue of existing stocks will call for either a major change of position on the part of one of the key participants or some very creative diplomacy. In regard to the latter, at least three broad approaches for dealing with existing stocks in the context of FMCT negotiations are conceivable and may warrant further discussion. None of these approaches seeks to use a FMCT as a nuclear disarmament measure. These are:

- signal the international community's interest in dealing eventually with existing stocks but set the issue aside for now, to be addressed later through follow-on actions and negotiations;
- require declarations of existing stocks of plutonium and HEU produced for weapons under a FMCT; or
- seek enhanced voluntary transparency and controls on all plutonium and HEU parallel with FMCT negotiations, whether unilateral or multilateral.

I will consider each possible approach in turn, including its dimensions as well as its pluses and minuses.

Send a Signal and Set the Issue Aside

This approach begins from the premise that the top priority in the cut-off negotiations is two-fold. First, a cut-off seeks to turn an apparent *de facto* cessation of the production of plutonium and HEU for nuclear weapons on the part of the five NWS into a formal treaty ban. Second, a cut-off can help contain the risk of a nuclear arms race in South Asia, while capping the nuclear weapon programmes of India, Pakistan and in the Middle East, Israel. The "send a signal" approach recognizes, however, that there is considerable interest in many quarters in greater transparency over and eventual reductions of existing stockpiles of nuclear weapons materials.

Balancing these considerations, this approach would begin by seeking to include appropriate language in the preamble to a FMCT to signal the international community's interest in further steps by the parties to deal with this matter. Partly modelled on preamble of the 1963 Limited Test Ban

Treaty, such language could take many forms. It might range from a very general recognition of the importance placed by many countries on new measures to address this question to more specific undertakings. Among the latter might be, for example, expressions of the parties' intent, in so far as practicable, to bring additional surplus weapon materials under international safeguards, to enhance transparency concerning their stocks, or to reduce and eventually eliminate all stocks of nuclear weapon materials. A general reference looking forward to future negotiations to extend international regulation of nuclear weapon materials might also be included.

This approach clearly would fall far short of what proponents of including existing stocks in a FMCT are seeking. For now, it also would likely go beyond what many of the NWS or nuclear-capable states would find acceptable. At the right point in the negotiations, however, it could become attractive as a means to conclude a cut-off deal.

Required Declarations of Nuclear-Weapons Materials under a FMCT

A FMCT could include provisions for its parties to declare their existing stocks of plutonium and HEU produced for use in nuclear weapons. To avoid revealing sensitive information about weapon design, such declarations could focus on aggregate stocks and not require details on the isotopic composition of the stocks.

Though limited in scope, declarations of stocks of plutonium and HEU by the five NWS would help to provide a needed foundation for later steps beyond a production cut-off. In particular, without more information about how much weapons material was produced during their Cold War competition, neither Washington nor Moscow is likely to be prepared to move toward extremely low levels of nuclear weapons. Comparable declarations by the other three NWS could also be a useful step towards their eventual involvement in five-power nuclear discussions.

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Required declarations by the five NWS, nonetheless, would still fall short of what proponents of including restrictions on existing stocks in a future FMCT are likely seeking — quite possibly provisions for the steady, if perhaps phased, elimination of such stocks under a FMCT. Many of these advocates, moreover, would likely regard this approach as going too far to "legitimize" the nuclear status of India, Pakistan and Israel. Even so, most of the NWS would probably be very reluctant to make such declarations. Depending on the country, concern about the accuracy of a declaration and fear of being embarrassed later, traditional secrecy and scepticism about transparency, concern about getting onto a "slippery slope" leading to future controls on stocks, and a desire to preserve ambiguity all could explain that reluctance.

It remains an open question, moreover, whether greater transparency by India, Pakistan and Israel would serve regional stability. Were India's stocks of plutonium more or less comparable in terms of weapon equivalents to Pakistan's stocks of HEU, disclosure could make it easier for the two countries to achieve their stated goal of minimum nuclear deterrence. An imbalance favouring either side, by contrast, could well fuel domestic and bureaucratic pressures for an arms race. In turn, an Israeli declaration that it had stocks of separated plutonium would reverse long-standing denials and quite possibly reinforce proliferation incentives in at least several Arab countries. That said, it must be expected that each of these three nuclear-capable countries would be very reluctant to declare openly what stocks of fissile materials it had on hand. Contrasted with the five NWS, moreover, it is difficult to identify sufficiently compelling countervailing considerations that might overcome that reluctance.

Enhanced Voluntary Transparency and Controls Over Stocks

Recognizing the difficulties of mandating transparency within a FMCT, a somewhat related compromise approach would seek to craft a set of voluntary transparency and control actions that might be taken by FMCT parties. For instance, at the time of signing, all five of the NWS could make a joint voluntary declaration of the existing stocks of HEU and plutonium in their weapons programmes. They might also be urged to make a further joint declaration committing them to work toward placing all surplus materials under IAEA controls. For their part, the three nuclear-capable states could be encouraged to declare all their stocks of plutonium and HEU without specifying the purpose for which it had been produced. All other producers of plutonium and HEU could be encouraged to make public declarations of their stockpiles, even though this material would have been produced for peaceful purposes.

As above, such voluntary declarations would help provide a foundation for later nuclear disarmament steps, while beginning to integrate the three medium-sized nuclear powers into the process. A commitment by the United States and the Russian Federation to place surplus nuclear materials from future reductions under international control could help create options for later, more far-reaching nuclear control and reduction measures. In turn, transparency measures that covered all fissile materials regardless of end use could help blur the distinction between production for weapons and for other end uses. This might lessen the extent to which release of such information in connection with a FMCT would comprise *de facto* recognition of India, Pakistan and Israel as nuclear-weapon states. Greater transparency by other countries of plutonium or HEU in their civilian nuclear fuel cycles could serve a comparable purpose. In turn, it might be somewhat easier for India, though not for Israel or Pakistan, to reveal its total stocks of plutonium since it has significant stocks of unsafeguarded but not necessarily weapons-related plutonium.

Regarding feasibility, over the past half-decade the United States has taken the lead in releasing information about its stockpiles of nuclear weapons materials and in placing some stocks of surplus materials under IAEA safeguards. The United Kingdom has also taken steps to enhance transparency, while the Russian Federation has said it will take some steps in the future. Thus, these countries might find the idea of voluntary transparency somewhat more palatable than required declarations. But even here, there is likely to be considerable reluctance on the part of the five NWS to take this step for many of the reasons already highlighted. Nonetheless, it is not inconceivable that they would be ultimately prepared to do so were that the price of a cut-off that included the three nuclear-capable countries.

In that regard, however, there is little reason for optimism that India and Israel would find voluntary transparency much less onerous than obligatory declarations in a FMCT. This is likely for Pakistan as well. Although Islamabad has argued for including existing stocks in a FMCT, that position may have been designed most of all to block the start of negotiations. Instead, Pakistan (like India and Israel) would likely view a commitment to make such declarations as a first step on a slippery slope to future controls. Both India and Pakistan also could be reluctant to do so lest such

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declarations reveal a significant gap in available stockpiles in the other's favour. Questions need to be raised as well about the stability impacts in both South Asia and the Middle East of even only voluntary transparency measures. Absent perceived sufficiency, the nuclear arms race would be accelerated — not capped — by cut-off.

What's in a FMCT – for Whom?

Most importantly, getting from here to there in the negotiating process presupposes that all of the key potential participants in a FMCT — the five NWS, the three nuclear-capable countries, and more activist non-nuclear developed and developing countries — conclude that a FMCT would on balance serve their political and security interests. It is far from assured that these countries will reach that conclusion. Though negotiations have begun, each of the three nuclear-capable states has serious reservations about the desirability of a cut-off. In turn, not only do important substantive political differences exist, but what some key countries appear to want in a FMCT is at least for now diametrically opposed to what others may be seeking — particularly with regard to the two matters already discussed of verification and existing stocks. Let's consider in somewhat more detail possible thinking in each set of countries — the five NWS, the three nuclear-capable states, and the more activist developed and developing countries.

The NWS

For the NWS, support for a FMCT would be one way to take action to meet their nuclear disarmament goals under Article VI of the NPT. The significance of this action as a preparatory step toward deep nuclear reductions would be enhanced were it possible either to include some transparency measures for existing stocks in a FMCT or to take that step voluntarily as part of the overall cut-off endgame. Even without a transparency adjunct, formalizing a ban on production of HEU and plutonium would be a useful psychological and symbolic step ahead. Assuming universal adherence, a cut-off would help cap proliferation in both South Asia and the Middle East.

But other more country-specific considerations are also likely to come into play — both for and against a cut-off. For both the United States and the Russian Federation, a cut-off would reinforce the irreversibility of their nuclear reduction process. This could take on added importance to both countries if the formal nuclear arms control process remains stalled — or is temporarily derailed by the two sides' inability to work out agreed amendments to the 1972 Anti-Ballistic Missile Treaty as are now being sought by the United States to permit deployment of a limited national missile defence system. Both countries also would have an interest in using a FMCT to draw China further into the nuclear arms control process. For China, a readiness to formalize a ban on production would pay dividends in terms of signalling that its nuclear modernization goals are limited, thereby helping to head off new nuclear competition with the United States. A universal FMCT also would contain the future expansion of India's nuclear capability, though it is uncertain how much China pays heed to India's actions.

Other considerations, however, could undermine support in these countries for a future FMCT, particularly a very ambitious treaty. As already noted, at least several of the NWS may be reluctant even to release information about existing stocks, while none of them seems prepared now to agree to more fundamental controls. Costs of verification also could come into play. For China, the risks of foreclosing the option of a major expansion of its nuclear arsenal are likely to be an issue in its internal debate. Chinese differences with the United States and Japan over the issue of the legitimacy of cooperative efforts to field a theatre missile defence against the missile threat of the Democratic People's Republic of Korea also could enter into a future debate in Beijing on cut-off.

The Three Nuclear-Capable States

Since the revival of interest in a FMCT in the early 1990s, the context in which decisions about cut-off will be made in Delhi, Islamabad and Jerusalem has changed considerably. In South Asia, this change may make it more likely that a FMCT will be reached. In the Middle East, these changes may make it less likely — at least for now.

Perhaps paradoxically, the testing of nuclear weapons by India and Pakistan in May 1998 may have made both countries more prepared to contemplate entry into a FMCT. Since the nuclear tests, the leaderships in both countries have argued that they are committed to avoiding the type of expanding deployments of nuclear arms and intensifying hostility that characterized the American-Soviet nuclear relationship. Instead, they have affirmed that their goal is mutual minimum nuclear deterrence. For several reasons, both India and Pakistan could well conclude that a ban on production of plutonium and HEU would help serve that goal. Like their adherence to the Comprehensive Test-Ban Treaty (which now appears in the offing), adherence to a FMCT would be a further political signal of each side's desire for restraint. More directly, limitations on stocks of materials would build-in a technical brake on the further expansion of each side's nuclear force capability. In both cases, a cut-off could help lessen domestic and bureaucratic pressures to "do more".

Perhaps paradoxically, the testing of nuclear weapons by India and Pakistan in May 1998 may have made both countries more prepared to contemplate entry into a FMCT. Since the nuclear tests, the leaderships in both countries have argued that they are committed to avoiding the type of expanding deployments of nuclear arms and intensifying hostility that characterized the American-Soviet nuclear relationship.

Both countries' adherence to a FMCT presupposes, however, that the issue of existing stocks be resolved in a manner acceptable to them both. This will not be easy. As noted, for now Pakistan argues that at the very least a FMCT should include declarations of existing stocks, while India opposes this position. There are several possibilities. Pakistan could conclude that its stocks of weapon materials are sufficient for a minimum deterrent, that it is better to constrain India's future production than to let it run free, and then fall off its effort to include existing stocks in a FMCT. Or India could shift ground, perhaps agreeing to voluntary declarations of all stocks of plutonium and HEU. Both sides might informally exchange data on stockpiles between them, taking the issue off the agenda but raising the risk of instability if those stockpiles were perceived to be significantly out of balance.

Shifting regions, the situation in the Middle East since the early 1990s is quite different. Israel has acquiesced in the start of formal cut-off negotiations. But the peace process is stalemated and long-term security trends are uncertain. In particular, continuing concerns about Iran's pursuit of nuclear-armed ballistic missiles have now been joined by the prospect of a reconstitution of Iraq's nuclear weapon programme with a breakdown of the international consensus behind UNSCOM. Both possibilities make it all but certain that Israeli leaders will be extremely reluctant to foreclose future nuclear options. Such reluctance to adhere to a cut-off would only be reinforced, to repeat, were it to include provisions governing existing stocks.

The implications of this appraisal will not be welcome in many quarters. At least in the near term, a universal FMCT may prove unattainable. Instead, it may be especially important to craft the entry into force provisions of a FMCT in such a manner as to make the achievement of a universal cut-off an eventual goal but not to hold the treaty's entry into force hostage to adherence by all three nuclear-capable countries.

Non-Nuclear Developed and Developing Countries

Turning to the third set of countries, there again is reason for concern. Assuming that the five NWS remain opposed to including existing stocks in a FMCT, opinions will differ among non-nuclear countries on the importance of a FMCT. Some of these countries may well welcome even a simple ban on production as an important political and psychological step by the five NWS. It partly closes the book on the Cold War nuclear competition and moves these countries a little further along the slippery slope to drastic reductions in — if not elimination of — nuclear weapons. If some or all of the nuclear-capable states also join, a FMCT would be welcomed, as well, as a cap on these countries' programmes.

By contrast, proponents of a more ambitious FMCT, as already noted, will argue that unless a cut-off controls existing stocks, it will not be meaningful. It will have little impact on the nuclear arsenals of the NWS, especially the United States and the Russian Federation since both countries already possess ample, indeed excessive, stocks of nuclear weapons materials. In addition, more activist countries can be expected to argue that controlling existing stocks is essential to roll back the nuclear programmes of India, Pakistan and Israel. Otherwise, in their view, a cut-off will "legitimize proliferation". In turn, a good number of non-nuclear countries are likely to argue that unless a cut-off includes all three nuclear-capable states, its value would be even more modest.

But in the endgame, the odds are high that proponents of more ambitious versions of a cut-off will confront a dilemma: whether to go along with a streamlined cut-off that at least initially is not universal — or to have no cut-off at all.

Voluntary transparency measures or a commitment to future negotiations, were these steps feasible, would be a potential sweetener. For their own reasons, India, Pakistan and Israel all could decide to adhere to a FMCT that included such voluntary measures. But in the endgame, the odds are high that proponents of more ambitious versions of a cut-off will confront a dilemma: whether to go along with a streamlined cut-off that at least initially is not universal — or to have no cut-off at all.

FMCT – A Bottom Line

Long part of the nuclear disarmament agenda, negotiations have finally begun on a treaty to cut-off the production of plutonium and HEU for weapons. But given the diversity of interests and approaches among the negotiating parties, getting from the start of negotiations to the successful conclusion of a treaty will likely prove very difficult. Pursuit of a more streamlined FMCT — in terms of scope of verification, treatment of existing stocks and evolutionary universality — could ease the negotiating process. It would do so admittedly at the expense of deferring for now more ambitious goals and with no firm assurance of success. The alternative, however, may be long, drawn-out negotiations, eventually ending nowhere.

Notes

1. In this paper, NWS will refer only to those five countries recognized as such in the NPT.
2. In May 1995, the so-called Shannon Mandate to establish a CD working group on a cut-off did not explicitly deal with the matter of existing stocks. As Ambassador Shannon's report noted, however, no delegation was precluded from raising any other issue related to a cut-off's scope. This understanding still governs the now-commenced negotiations at the CD.

Fissile Material Treaty: Negotiating Approaches

Tariq RAUF

Five years have elapsed since United Nations General Assembly resolution 48/75L, of 16 December 1993, called for the negotiation of a non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons and other nuclear explosive devices, in the most appropriate forum.[1] The Conference on Disarmament (CD) then decided on 25 January 1994 to appoint a Special Coordinator to solicit the views of the CD membership on such a treaty, and that it was the appropriate forum. After much confused and muddled discussion among CD members, a weak and incomplete negotiating mandate was finally agreed on 23 March 1995 just a few weeks prior to the opening of the 1995 Nuclear Non-Proliferation Treaty (NPT) Review and Extension Conference. The 24 March 1995 report of the Special Coordinator (CD/1299), Ambassador Gerald Shannon of Canada, contained an agreed mandate that basically repeated the operative language from resolution 48/75L together with the understanding that all issues pertaining to scope could be addressed in the context of the treaty negotiation — hence, the key differences were fudged, and the Shannon report and mandate reflected the maximum agreement possible at the time, given the sharp differences in the negotiating positions of states as well as in their objectives for a fissile material control treaty (FMT).

Both resolution 48/75L and the "Shannon report and the mandate contained therein" essentially glossed over certain crucial issues relating to the negotiation of any non-discriminatory and multilateral treaty controlling weapon-usable fissile material. Differences over the scope and other important issues prevented the adoption of any other General Assembly resolutions from 1994 through 1997, and stymied any progress at the CD until 11 August 1998 when preliminary negotiation started on the basis of CD/1299. On 4 December 1998, General Assembly resolution 53/77I was adopted by consensus and it encouraged the CD to resume negotiation on a FMT during its 1999 session on the basis of the Shannon report and its mandate — thus, in reality, while important progress has been achieved in reaching agreement at the CD on the expertise of Ambassador Mark Moher (Canada) to chair an Ad Hoc Committee on a FMT, in terms of the mandate we are no further ahead than the compromise of March 1995 and none of the key differences in approach, scope, objectives, etc. for such a treaty have been bridged.

While the article in this issue of *Disarmament Forum* by Victor Bragin and John Carlson deals with significant divisions in the scope debate, for the purposes of the present discussion it would be

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useful to list some of the basic issues underlying the scope of obligations for a FMT, some of which are:

- verifiable production halt;
- assured prevention of diversion of civilian fissile material to weapon use;
- verified accounting of all past production;
- assured prevention of rededication of excess weapons fissile material for reuse for military purposes;
- prohibition on sequestering weapon-usable fissile material for future military use; and
- inventory control and safeguarding of all existing stocks of weapon-usable fissile material (except for material contained within intact warheads, or material already especially manufactured for warheads but not yet shaped into cores/pits).

The present situation regarding unsafeguarded production of weapon-usable fissile material is that the United States, the United Kingdom and France have separately and unilaterally ceased production, while only France has permanently retired its production facilities. The Russian Federation claims that it is not producing, however two plutonium production reactors will remain operational at least until 2000. China's position remains unclear, though unsubstantiated high-level reports suggest a production moratorium. Both India and Pakistan apparently are still building up stocks, and Israel's position remains unclear. Production and/or use of highly enriched uranium (HEU) and plutonium in all other countries is under NPT-related IAEA safeguards (except for Cuba, which has not yet joined the NPT).

This paper discusses definitions of some terms relevant to the Shannon Mandate, outlines current approaches, assesses some of the inadequacies of the traditional approaches and suggests a new, pragmatic approach to a FMT negotiation with a view to securing a halt in new production, as well as achieving accountability and transparency regarding existing stocks and past production.

Definition of Terms

In the context of revisiting the FMT negotiation with a pragmatic approach, it would be appropriate to reach a common understanding on the definition of terms as they appear in the Shannon report and in General Assembly resolution 53/77I.[2]

NON-DISCRIMINATORY

Given the events of May 1998 and the undesirability of recognizing any new NWS, an appropriate interpretation of non-discriminatory could be in terms of a FMT as equally applicable to all states possessing unsafeguarded weapon-usable fissile material and to those states where all fissile materials are under safeguards.

The traditional interpretation of this term refers to a FMT that would be equally applicable to all states, irrespective of their status as nuclear-weapon states (NWS), non-nuclear-weapon states (NNWS) or threshold states. However, given the events of May 1998 and the undesirability of recognizing any new NWS, an appropriate interpretation of non-discriminatory could be in terms of a FMT as equally applicable to all states possessing unsafeguarded weapon-usable fissile material and to those states where all fissile materials are under safeguards. Another interpretation of non-discriminatory refers to the purpose of a FMT — is it aimed at nuclear non-proliferation or nuclear disarmament? While it is clear that some of the NWS regard a FMT as essentially a non-proliferation measure, now that proliferation has occurred in South Asia, there is no option other than regarding a FMT as serving the twin objectives of nuclear non-proliferation as well as nuclear disarmament. Hence, in order to be effective and credible, a FMT would have to ban future production and also bring all unsafeguarded stocks of weapon-usable fissile material under bounded or managed transparency.

Yet another meaning of non-discriminatory could be formulated in terms of not disadvantaging any among the five *de jure* NWS and the three *de facto* NWS. Thus, discrimination would need to be avoided at two levels: 1) in terms of available stocks of weapon-usable material — most of the five NWS already possess sufficient or even excess stocks, whereas both India and Pakistan apparently want to continue with production for some time, and Israel's position remains unclear; and 2) in terms of providing for international monitoring or safeguards that would apply equally and evenly in all states possessing unsafeguarded stocks of weapon-usable fissile material (as well as in those NNWS where such material either does not exist or, if it exists, is under safeguards). Thus, in practice, there appears no good or truly non-discriminatory way of reconciling the different interpretations that could be ascribed to the term non-discriminatory as it is used in CD/1299 or 48/75L, other than agreeing on a definition that uniformly treats all eight states with unsafeguarded weapon-usable fissile material. Consequently, a FMT would necessarily need to capture both a halt on future production as well as accountability and transparency of all existing stocks (except for material contained within intact warheads, or material already especially manufactured for warheads but not yet shaped into cores/pits), as well as establishing uniform verification and monitoring measures for weapon-usable material in all states parties. HEU for naval or space propulsion reactors would also require to be under appropriate accounting and transparency measures, as new technologies permit long-lived fuel, thus eliminating the need for refuelling.

There appears no good or truly non-discriminatory way of reconciling the different interpretations that could be ascribed to the term non-discriminatory as it is used in CD/1299 or 48/75L, other than agreeing on a definition that uniformly treats all eight states with unsafeguarded weapon-usable fissile material.

MULTILATERAL

Again, the traditional interpretation would refer to a FMT involving multiple parties, which could mean all United Nations Member States, all CD members or all states with nuclear facilities or materials; or it could also mean "global" or "universal" — i.e. all NWS (*de jure* plus *de facto*) as well as all NNWS. A strict definition, however, would argue for a meaning of "multilateral" as referring to several international parties, but not necessarily to be global or universal. But it could also be ascribed a differential interpretation—i.e. that a FMT, in the first instance, could be negotiated "multilaterally" among the eight states operating unsafeguarded nuclear production facilities and possessing unsafeguarded stocks of weapon-usable fissile material (hereafter refereed to as the U-8) or some combination thereof, in consultation with other countries both within and outside the CD, with other countries participating and contributing to the negotiation at a later stage prior to achieving a final treaty text.

Internationally and Effectively Verifiable

There seems to be general recognition that the IAEA would have to be closely involved with the verification of a FMT, and that the safeguards obligations must apply uniformly to all states, regardless of their NPT or safeguards status. (See article in this issue by Thomas Shea.) However, the applicability of the existing IAEA safeguards mechanisms to a FMT would need to be carefully assessed, because certain technical parameters such as "significant quantities", "timeliness goal" and "material balance areas" might be different for a FMT than those under IAEA safeguards. Furthermore, it must be recognized that in many cases, facilities in NWS and in some other states were designed for military purposes exempt from safeguards, hence their monitoring will pose technical challenges and it will be important to prevent both tangible and intangible proliferation. In this context, the American-Russian working group on safeguards, transparency and irreversibility (STI) will have much to contribute regarding specific measures on improving confidence and increasing transparency and irreversibility of safeguards on weapon-usable fissile material. Furthermore, under the Trilateral Initiative involving the United States, the Russian Federation and the IAEA, consultations are ongoing to develop a model verification agreement for weapon-origin fissile materials, which would allow IAEA verification of any weapon-origin fissile material as well as any other material released from military programmes. Such verification techniques would also be relevant to a FMT.

Production

Does this refer exclusively to future production, to past production or to all production to date? While the 1993 and 1998 General Assembly resolutions refer to a "treaty banning the production of fissile material for nuclear weapons ...", the Shannon report does not preclude any delegation from raising issues concerning past production during a FMT negotiation. It is unrealistic to believe that a FMT could be negotiated without discussing the concept of "production" in all its aspects and finding ways of capturing past production or indeed all production up to the entry into force of a FMT. A FMT that directly or indirectly serves to "grandfather", "legitimize" or exclude existing unsafeguarded stocks of weapon-usable fissile material would not be worth the paper it's written on and it would pose a grave threat to the integrity and efficacy of the present global nuclear non-proliferation regime structure.

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Negotiating Approaches

As regards the actual negotiation of a FMT, a number of approaches have been advanced over the years. These include the General Assembly resolutions of 1993 and 1998, the report of the Special Coordinator and the mandate contained therein, the positions of, for example, Egypt, India, Pakistan and the United States, and the Australian approach outlined at the1998 NPT Preparatory Commission (PrepCom). At one level, the differences in approach emanate from the respective stated objectives of a FMT — nuclear non-proliferation and/or nuclear disarmament. At another level, differences pertain to the so-called incremental or phased approach to nuclear disarmament versus a time-bound framework for the complete elimination of nuclear weapons. Recently, some Western NGO analysts have taken to asserting the "superiority" of a phased approach over a time-bound framework. From a purely pragmatic and functional perspective, neither approach is inherently superior to the other — both have their respective failings — hence the importance of avoiding rigidity, while favouring flexibility and pragmatism. In this context, a FMT must necessarily have the dual objectives of promoting both nuclear non-proliferation and nuclear disarmament if it is to have any relevance for enhancing global security and bringing transparency and accountability to weapon-usable fissile materials in the U-8 states.

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Devising an appropriate and practical negotiating approach for a FMT remains problematic. Thus far, the traditional approach has focused only on a simple production cut-off. Given the lack of progress, Australia and Japan have suggested a two-phase approach whereby a production cut-off would be followed by a second agreement dealing with transparency in stocks. Despite the stalemate in the CD from 1994 through mid-1998, a number of important developments have taken place on the sidelines with respect to increasing transparency and accounting of certain types of fissile materials — notably the American-Russian STI initiative and the plutonium management guidelines. Given the inadequacy of all of the present approaches, this paper proposes a new, pragmatic approach that seeks to bridge differences and pursues a FMT with the dual objectives of promoting both nuclear non-proliferation and nuclear disarmament, as achieving one is impossible without the other.

Traditional Approach

The traditional approach as agreed in General Assembly resolution 48/75L would prohibit only future production and would bring existing production facilities under verification for non-production. This minimalist approach at one level reflected the American preference for utilizing a FMT as a non-proliferation vehicle to "capture" India, Israel and Pakistan — i.e. to limit their stocks of weapon-usable material to existing levels and to verifiably ban further production — while allowing the NWS to retain their respective stocks minus those quantities unilaterally declared excess for defence purposes. At another level, this minimalist approach reflected the maximum degree of agreement that could be achieved, given the strong objection to including existing stocks by the NWS, India and Israel. The potential advantages of this traditional approach would be to:

- verifiably halt further production, both in the NWS and in the non-NPT states;
- constitute a further step in the phased approach to nuclear disarmament, in keeping with the 1995 NPT Review and Extension Conference (NPTREC) principles and objectives; and
- bring some transparency to materials/facilities in the NWS, especially in the Russian Federation and China, as well as in the non-NPT states operating unsafeguarded production facilities.

These advantages, however, are eclipsed by the disadvantages, as such a limited FMT would:

- retain excessively large stocks of unsafeguarded weapon-usable fissile materials in the NWS, with no limitations on their reintroduction into new weapons;
- not bring about transparency regarding quantities or composition of weapon-usable fissile material; and

- serve to "grandfather" or "legitimize" existing stocks in the non-NPT states, thus creating not only another layer of discrimination but also enhancing proliferation risks.

Two-Phase (Australian/Japanese) Approach

At the 1998 NPT PrepCom, Australia presented a "concept paper" on 29 April, which argued that "a fissile material cut-off treaty should not be seen as a stand-alone instrument — like the Comprehensive Nuclear-Test-Ban Treaty (CTBT) — which seeks to address fissile material issues in one fell swoop, but rather as a framework instrument which evolves into a comprehensive regime governing the production, stockpiling, management and disposition of fissile material."[3] This would involve a first step codifying a ban on production—which can and should be taken now; followed by a second agreement providing for greater transparency over fissile material inventories and gradually bringing fissile material stocks under strict and effective international control. This second agreement too would be an "evolving instrument" that tracks other nuclear disarmament measures and progressively brings direct-use fissile material into the scope of a fissile material regime. This two-phase approach regards a FMT "as an essential and unavoidable step towards the elimination of nuclear weapons". The principal rationale underlying this approach is to "lock in" and "fix in a legally binding multilateral instrument" the current moratoria by the NWS on weapon-usable fissile material production, before the moratoria have a chance of dissipating. In addition, it seeks to capture unsafeguarded production facilities in non-NPT states, as it believes that a FMT "which did not include these states would have little or no chance of succeeding". Furthermore, if a FMT "is to be a genuine disarmament measure ... then it will have to be capable of evolving in tandem with other disarmament measures" — hence a first step of achieving only a ban on further production. And since "sooner or later, multilateral verification of both fissile material production facilities and fissile material stockpiles" would need to be included, a second agreement would be necessary.

In a "(draft) working paper" circulated at the 1998 NPT PrepCom, Japan proposed "universal transparency of fissile material"[4] to follow the conclusion of a FMT, taking into account the need to prevent disclosure of sensitive information in the context of nuclear non-proliferation.

At first glance, the Australian (and Japanese) approach seems reasonable and possibly achievable. However, it does not fully meet an important criterion identified in the Australian paper, i.e. "we have to recognize and take into account ... national security imperatives, and regional security dynamics, which underlie the different positions that the non-NPT states have adopted on the proposal for a cut-off treaty." It is unrealistic to assume that India, Israel or Pakistan would readily agree to a treaty banning only future production without some linkage to some other issue, be it nuclear disarmament, regional security or differences in existing stocks. Furthermore, there is no certainty that were only a ban on production to be agreed, the NWS or the non-NPT states would then automatically go on to agree to a far-reaching second agreement on stocks. Given the backtracking of the NWS regarding their promises and commitments made at the 1995 NPTREC, it would take an unusual leap of faith in the credibility of the NWS to deliver on a second agreement once they had a production halt in the bag! And it is unrealistic given the reluctance of India to place its stocks on the table absent a negotiation on a time-bound framework for nuclear disarmament, the opposition of Israel to discussing its stocks or production outside the context of a comprehensive regional security system, and Pakistan's fear of being permanently locked into a position of material inferiority *vis-á-vis* India.

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Complimentary Sideline Approaches

Separate from the CD track, some important progress has been achieved on the sidelines.[5] The United States took the lead in declassifying the total amount of weapon-grade plutonium produced since 1945, consumption over time, disposition and location, and quantities declared surplus to defence requirements that would be placed irreversibly under voluntary safeguards.[6] Reportedly, it will soon release a similar accounting of its HEU. The United Kingdom, as part of its recent Strategic Defence Review, has provided some details on its holdings of weapon-usable fissile material.[7] France too has provided some information. However, neither China nor the Russian Federation has yet provided an accounting of their respective stocks. Furthermore, under their 1995 "declarations on transparency and irreversibility", the United States and the Russian Federation have agreed not to reuse excess weapons fissile materials for new nuclear weapons, not to use any newly produced materials in weapons, and not to divert fissile materials from civil nuclear programmes to weapons use. And in September 1998, the two countries signed a joint statement of principles for management and disposition of plutonium designated as no longer required for defence purposes, including a commitment to develop acceptable methods and technology for transparency measures, as well as appropriate international verification measures. Furthermore, under their Trilateral Initiative, the United States, the Russian Federation and the IAEA are working on developing a model verification agreement that would allow the verification of weapon-origin fissile material. In a separate but related development, on 1 December 1997, plutonium management guidelines were agreed among nine states: Belgium, China, France, Germany, Japan, the Russian Federation, Switzerland, the United Kingdom and the United States.[8] These guidelines cover separated plutonium, plutonium contained in unirradiated mixed oxide fuel elements, plutonium contained in other unirradiated fabricated goods, and plutonium in the course of manufacture or fabrication or contained in unirradiated goods in the course of manufacture or fabrication; and apply to the management of all plutonium in all peaceful nuclear activities, and to other plutonium after it has been designated as no longer required for defence purposes. The guidelines require annual reporting on all plutonium subject to the guidelines, implementation of physical protection measures, as well as an effective system of nuclear material accountancy and control. On 11 November 1998, the IAEA published data on "annual figures for holdings of civil unirradiated plutonium" and for "estimated amounts of plutonium contained in spent civil reactor fuel" provided by Belgium, France, the Russian Federation and the United Kingdom.[9] Earlier, on 30 October 1998, the IAEA published "annual figures for holdings of civil highly enriched uranium" provided by the United Kingdom.[10] Even though these gross declarations refer to civil holdings of fissile material, the modalities agreed in these guidelines could be useful in devising a framework for declarations of weapon-usable fissile material with relevance to a verification regime for a FMT. Together, these developments indicate the beginning of a serious discussion on transparency, verification and accountability of special fissionable material among a small number of key advanced industrial states, which could be of direct relevance to a FMT negotiation in the appropriate context.

Inadequacy of Existing Approaches

The FMT negotiation as presently conceived remains fraught with serious problems and deficiencies. Any FMT that does not explicitly and specifically deal with all existing stocks in the U-8 states would neither serve a non-proliferation goal nor a disarmament objective. While in theory a two-phase approach seems attractive — a production halt followed by transparency in stocks — in reality there is no certainty that a second, follow-on agreement on stocks could be reached. This is the fatal flaw in such an approach, as there would be little incentive for the three non-NPT states with unsafeguarded weapon-usable material to negotiate a production halt without foolproof assurance that the NWS would indeed place their respective stocks under a transparency regime.

It is an orthodoxy of the Cold War era, unthinkingly legitimated since 1993, that a FMT necessarily must be multilaterally negotiated along traditional lines. The CTBT experience suggests that the days might be over for multilaterally negotiated grand nuclear arms control agreements. The NPT and the CTBT adequately capture the NNWS, which are prevented under the NPT from having nuclear weapons and under the CTBT from any type of nuclear explosive testing. Hence, a further restriction upon them under a FMT would be redundant and their active participation in a line-by-line negotiation based on a consensus rule would not necessarily contribute much and could possibly delay the conclusion of a FMT. In the context of the FMT negotiation, would it not be practical and starkly realistic to define "multilateral" in the first instance as meaning those states operating unsafeguarded production facilities and possessing unsafeguarded stocks of weapon-usable fissile material (the U-8) rather than the entire membership of the CD or of the United Nations?

In the context of the FMT negotiation, would it not be practical and starkly realistic to define "multilateral" in the first instance as meaning those states operating unsafeguarded production facilities and possessing unsafeguarded stocks of weapon-usable fissile material (the U-8) rather than the entire membership of the CD or of the United Nations?

It would be far more efficient and practical for the U-8 to take the lead in preparing a FMT draft — in consultation with the CD membership to ensure comprehensiveness and transparency — that would deal with both a prohibition on any new production and include provisions for bounded transparency on existing stocks. Under present circumstances, it should not be an absolute requirement for a FMT to include provisions on the disposition of existing stocks. As such, a FMT should concern itself with halting further production and bringing existing stocks and production facilities under managed monitoring. The final disposition and eventual destruction of existing stocks and stocks emanating from dismantled weapons could be deferred to a future treaty dealing with the prohibition of nuclear weapons.

A New, Pragmatic Approach

Since 1993, for the most part, the discussion on FMT issues both within and outside the CD has tended to focus on the traditional approach to dealing multilaterally with nuclear non-proliferation matters. Hence, the traditional trichotomy of categorizing states as NWS, NNWS and threshold states. The eleven nuclear detonations in South Asia last May have forever changed the nuclear non-proliferation dialectic and are forcing a change in how the world casts the distinctions between NWS and NNWS. While it would be imprudent to recognize any additional NWS, the realities are there for all to see in South Asia. Therefore, for the purposes of a FMT negotiation it is now necessary to "think outside the box" — to devise a practical, new approach that focuses on states with unsafeguarded direct-use weapon-grade fissile materials and those without, rather than the traditional categorization of NWS, NNWS and threshold states. Hence, the United States, the Russian Federation, the United Kingdom, France, China, India, Israel and Pakistan fall into the category of states with unsafeguarded stocks of weapon-usable fissile materials (the U-8). All other NPT states would continue to be regarded as NNWS, with all special fissionable material under IAEA safeguards.

The creation of a U-8 category of states, for the purpose of a FMT negotiation, has the advantage of getting beyond the vexatious problem of *de jure* and *de facto* NWS, or that of NWS in addition to the P-5, or of "rewarding" proliferators. It would also conform to the edict for a "non-discriminatory"

FMT — from a practical perspective, the distinction must be between states which possess unsafeguarded weapon-usable fissile material and those which do not, rather than between the standard NWS and NNWS.

The priority for any FMT must be to convert the existing production moratoria in some of the NWS into a binding, verifiable commitment, as well as to secure a similar commitment from the other NWS and from the three non-NPT states. Furthermore it must capture past production and current stocks in a realistic transparency regime.

Setting aside traditional thinking and moving to a pragmatic approach would suggest a FMT negotiation based on several interlinked components, as follows:

- Unilateral, reciprocal binding commitments by the U-8 to halt new production as of a certain date, for example, 1 January 2000 — this could take the form of a common agreed text;
- IAEA monitoring of the external perimeter of all production facilities as of a certain date, such that no feed material enters and no finished material exits (including warhead components or warheads), except for material designated for naval or space propulsion reactors (in which case the quantity and isotopic composition would need to be declared, the material tagged and monitored in transit through deployment into propulsion reactors, tagged upon recovery as spent fuel through monitored storage, or the naval reactors sealed and tagged if left in there for long-term storage. With the end of the Cold War there is no longer any credible case for exempting such material from accountability and transparency measures; furthermore long-lived naval nuclear fuel now permits new core designs to last in excess of thirty years or the normal life of a ship, thus eliminating the need for refuelling);[11]
- Establishment of "sanctuaries" comprising storage sites for existing stocks, with IAEA perimeter portal monitoring to ensure no outbound movements of stocks (except as provided for in the preceding paragraph above), inbound movement of excess weapons fissile material would be permitted;
- Exchange of baseline data on existing stocks between the U-8, which could also include isotopic declarations;
- Agreement on a target date of 1 April 2000 for conclusion of a composite working draft of a FMT text — which would be prior to the opening of the 2000 NPT Review Conference;
- The final disposition (and destruction) of production facilities and existing stocks (including excess weapons material) would be dealt with separately through a multilateral, legally binding instrument on the total prohibition of nuclear weapons;
- Two-phase negotiation leading to a FMT: first, through the Ad Hoc Committee, the CD should agree on a framework of indicative treaty headings; second, this would be followed by drafting of treaty language, primarily by U-8 but in full consultation with CD membership.

While it would be desirable to extend the production moratoria to cover all eight states with unsafeguarded production facilities and unsafeguarded weapon-usable material, present realities would suggest that such a multilateral (U-8) moratorium could only be achieved over time. As such, a deadline could be set for 1 January 2000 for securing unilateral production moratoria in the U-8, preferably through a common agreed text or through a FMT. However, during this period the NWS would agree neither to resume new production, nor to slow the pace of declaring surplus weapon fissile material, and the three non-NPT states would agree not to accelerate their production. The stocks of the NWS remain considerably in excess of the three non-NPT states and the gaps could be reduced but not closed by January 2000. Verification of non-production would take place through external perimeter monitoring by the IAEA; any methodologies developed through the Trilateral Initiative could be employed toward this end. Existing storage sites for weapon-usable fissile material would be designated as "sanctuaries", but no material could leave the sites (except as already discussed above). As a confidence-building measure, the U-8 could agree to exchange categorized and isotopic declarations (described below). Given the injunction of the 1995 NPTREC on a FMT, it would be politically important to set a deadline of 1 April 2000 for agreement on a basic draft text of a FMT, subject to final revision and agreement. A FMT under this approach would accomplish two objectives: it would verifiably halt further production and it would create bounded transparency and accountability of all existing U-8 stocks. The treaty would not be burdened with provisions governing final disposition and elimination of stocks of weapon-usable fissile material, which would belong to a future multilateral treaty prohibiting nuclear weapons.

A FMT under this approach would accomplish two objectives: it would verifiably halt further production and it would create bounded transparency and accountability of all existing U-8 stocks. The treaty would not be burdened with provisions governing final disposition and elimination of stocks of weapon-usable fissile material, which would belong to a future multilateral treaty prohibiting nuclear weapons.

The actual negotiation should be a seamless two-phase process. The CD should re-establish an Ad Hoc Committee to negotiate a FMT. In phase I of this pragmatic approach, the Ad Hoc Committee would draft and agree upon a framework of indicative headings for a FMT. This would involve agreeing on the framework of the scope of obligations as well as on the scope of verification and monitoring regimes, in addition to other procedural and technical aspects of a treaty. In the next phase, also with the involvement of the chair of the Ad Hoc Committee, the U-8 would take on the primary responsibility for drafting treaty language, but this would need to be done in close consultation with other states. Given the technical nature of the subject, it would be essential for delegations to include scientific advisors and other technically qualified personnel in the negotiation. Furthermore, sensitive and complex issues would need to be discussed in working or technical groups, however, it would be equally important not to allow technical discussions to bog down the negotiation. For negotiation on a FMT to be credible, it would be necessary to create a suitable climate of confidence by providing comprehensive disclosure of fissile material inventories designated by isotopic composition—this can be achieved without necessarily compromising sensitive design information or contributing to intangible proliferation. Some suggestions for disclosure are discussed next.

Declaration of Fissile Material

In the framework of a FMT as discussed above, data exchanges[12] by the U-8 on current stocks or past production of weapon-useable fissile material could take the form of any one of the types of declaration outlined below — the only exemptions would be for material contained within intact warheads, or material already especially manufactured for warheads but not yet shaped into cores/ pits.

Multilateral Comprehensive Declaration

- Categorized declaration of all weapon-usable fissile material inventories, categorized in terms of military and non-military stocks;
- Isotopic declaration of all weapon-usable fissile material inventories, categorized in terms of military and non-military stocks.

Phased Comprehensive Declaration

- Register of fissile material: phased or step-by-step gross declarations of all weapon-usable fissile material produced and currently held in all inventories;
- Categorized declaration of weapon-usable fissile material: phased or step-by-step comprehensive declarations of all weapon-usable fissile material produced and currently held in all inventories, categorized in terms of all military and non-military stocks;
- Isotopic declaration of weapon-usable fissile material: phased or step-by-step comprehensive declarations of all weapon-usable fissile material produced and currently held in all inventories, categorized by isotopic composition in all military and non-military stocks.

Unilateral Declaration

- Unilateral, simultaneous gross declarations of all fissile material produced and currently held in all inventories (the unilateral declaration by the United Kingdom as part of its Strategic Defence Review could serve as an illustrative example);
- Unilateral, simultaneous categorized declarations of all fissile material produced and currently held in all inventories, categorized in terms of military and non-military stocks;
- Unilateral simultaneous (phased) declarations of all fissile material produced and currently held in all inventories, categorized by isotopic composition in all military and non-military stocks.

Conclusion

The issue of a multilateral FMT has acquired a certain orthodoxy harking back to the Cold War. Through the Cold War, a FMT was conceived of primarily as a nuclear disarmament measure — a step by which to cut-off the material for the production of nuclear warheads by the five original nuclear proliferators. With the ending of the Cold War and the deep cuts in nuclear warheads under the INF and START agreements between the United States and the former Soviet Union, a FMT was portrayed by some of the NWS, notably the United States, as serving primarily a nuclear non-proliferation purpose. Furthermore, the impasse at the CD between those favouring an incremental, step-by-step approach to nuclear disarmament and those pushing for a time-bound framework for the elimination of nuclear arms, led to an artificial hierarchy of measures — i.e. the CTBT, followed by a FMT, accompanied by the START series of agreements and negotiations in good faith leading to nuclear disarmament and general and complete disarmament. Lost in this discourse was the practical, common-sense approach focusing on the roots of the proliferation/disarmament conundrum — i.e. the NWS and the three non-NPT states. While a grand FMT negotiated along the lines of the CTBT might be desirable, there is no pressing logic for following that tortuous and time-consuming path. In the aftermath of South Asian proliferation, one must liberate the arms control process from the lingering binds of the Cold War and shed the “old think” that has so heavily influenced the thinking on a FMT by both officials and NGO experts. Pragmatism and flexibility would recommend that a FMT, in the first instance, be drafted by the U-8 or whomever among their number are amenable to join a negotiation (without regard to their official or unofficial status). However this must be in consultation with other NNWS, so that there can be agreement on the general parameters of a treaty. For a FMT to be effective and credible, it must deal both with verifiably halting further production and with bringing transparency and accountability to existing stocks. And it must provide the framework and context leading in time to a global, legally binding instrument on the prohibition of nuclear weapons.

Notes

1. For the purposes of this paper, the term weapon-usable fissile material will apply to "fissile material for nuclear weapons and other nuclear explosive devices", i.e. highly enriched uranium and plutonium.
2. Ambassador Mark Moher provided his interpretation in a presentation to a workshop on "The Fissile Material Cut-off Treaty: Issues and Prospects", Geneva, 14 February 1997.
3. Statement delivered by H.E. Mr. John B. Campbell, Head of the Australian Delegation to the Second Preparatory Committee of the 2000 Review Conference of the States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons: Fissile Material Cut-Off Treaty, Geneva, 30 April 1998; and *Fissile Material Cut-off Treaty: Concept Paper*, 29 April 1998.
4. *(Draft) Working Paper (Japan): Some additional elements to be incorporated in the recommendations to the 2000 Review Conference,* Geneva, 29 April 1998.
5. For an interesting discussion, see George Bunn, Making Progress on a Fissile-Material Cut-Off Treaty after the South Asian Tests, *The Nonproliferation Review,* Spring/Summer 1998; see also Noboru Oi, Plutonium Challenges: Changing Dimensions of Global Cooperation, *IAEA Bulletin*, vol. 40, no. 1, March 1998, online at www.iaea.org.
6. See *Fact Sheet* on "U.S. Commitment to the Treaty on the Non-Proliferation of Nuclear Weapons", United States Arms Control and Disarmament Agency, 22 April 1998, pp. 5–8; and *Intervention by Mr. Norman A. Wulf, U.S. Delegation Head, Second NPT Preparatory Committee Meeting, Cluster I Discussion*, Geneva, 30 April 1998, pp. 7–13.
7. See Pearl Marshall, U.K. Pu Declaration Aimed at Boosting Geneva Fissile Material Talks Next Month, *Nuclear Fuel*, 14 December 1998, pp. 10–11.
8. See *Communication Received From Certain Member States Concerning Their Policies Regarding The Management of Plutonium*, INFCIRC/549, 16 March 1998, IAEA.
9. INFCIRC/549/Add.3/1 (Belgium), INFCIRC/549/Add.5/1 (France), INFCIRC/549/Add.9 (Russia), INFCIRC/549/Add.8/1 (United Kingdom).
10. INFCIRC/576.
11. See Glenn R. George and Lisa Megarle George, The Naval Reactors Program: From Nautilus to the Millenium, *Nuclear News,* October 1998, p. 31.
12. For useful discussions on disclosure, see *Comprehensive Disclosure of Fissionable Materials: A Suggested Initiative*, Discussion Paper by the Carnegie Commission on Preventing Deadly Conflict, New York, June 1995; and Brian G. Chow, Richard H. Speier, Gregory S. Jones, *The Proposed Fissile-Material Production Cut-Off: Next Steps,* RAND, 1995.

FMCT:
Some Significant Divisions in the Scope Debate

Victor Bragin & John Carlson

Successful completion of a Fissile Material Cut-off Treaty (FMCT) in the near future would be an important step towards the ultimate goal of eventual elimination of nuclear weapons. Of major importance to both nuclear disarmament and non-proliferation objectives, the FMCT would serve the security interests of all members of the international community and complement the Nuclear Non-Proliferation Treaty (NPT) and the Comprehensive Nuclear Test-Ban Treaty.

The FMCT will affect individual states differently due to the variance in their nuclear fuel cycles and pre-existing inventories of fissile material. Hence there are differences among national experts over what should be the ultimate aim of the FMCT and how it fits into the broader arms control, disarmament and non-proliferation processes. It is important to appreciate, however, that whatever the scope of the eventual FMCT, states that are parties to a comprehensive safeguards agreement — essentially non-nuclear-weapon states (NNWS) parties to the NPT — will by that fact alone satisfy the requirements of the FMCT. These states have undertaken not to produce or acquire nuclear weapons or other nuclear explosive devices, and to accept IAEA safeguards on all their nuclear material to verify the fulfilment of this undertaking. Therefore, the FMCT will substantively affect only those states that have not accepted comprehensive safeguards — the nuclear-weapon states (NWS) and the threshold states (TS).

Debate goes on about what specific materials and activities the FMCT should address. In terms of what the FMCT should cover, opinions span a wide spectrum — from a treaty of narrow scope, which would be limited to future production of weapon-grade material and associated facilities, to a comprehensive treaty resembling NPT safeguards. The problem is how to negotiate a treaty that is favourable for all participants, given that interests and priorities vary so much.

The authors have been invited to highlight some possible significant divisions in the scope debate that might arise in the FMCT negotiations. Accordingly it is not the aim of this short essay to present a systematic and comprehensive study on the scope of the FMCT and associated verification arrangements. Instead we formulate and discuss here some key issues related to the FMCT.

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What Should Be the State's Basic Commitment Under a FMCT?

Experts' opinions differ even over the fundamental issue of the state's basic commitment under the FMCT. It is widely accepted, and consistent with the Conference on Disarmament's decisions and United Nations resolutions, that the FMCT should prohibit production of fissile material for nuclear weapons or other nuclear explosive devices. Thus, it should be relatively easy for states to agree that upon entry into force each state party would undertake:

- not to produce fissile material for nuclear weapons or other nuclear explosive devices;
- not to use any fissile material that is subject to the FMCT for nuclear weapons or other nuclear explosive devices; and
- to accept international verification pursuant to the FMCT to provide assurance that fissile material is being produced only for non-proscribed purposes.

A FMCT based on these undertakings alone would comprise a substantial step towards the ultimate goal of nuclear disarmament.

Though some states have sought inclusion of stocks of fissile material existing at the time of the FMCT's entry into force, we believe most key states now appreciate that the only negotiable treaty is one that deals primarily with future production.

We assume that any eventual FMCT will focus on *future* production. Though some states have sought inclusion of stocks of fissile material existing at the time of the FMCT's entry into force, we believe most key states now appreciate that the only negotiable treaty is one that deals primarily with future production. If there is to be a successful outcome to the negotiations, we believe those states seeking the inclusion of pre-existing stocks will have to be prepared to recognize that securing a treaty applying to future production will be a very considerable achievement, of substantial benefit to the security interests of all participants.

What Nuclear Material Would Be Subject to Verification?

It is important to highlight the fundamental difference between verification arrangements under the NPT and the FMCT. Full-scope NPT safeguards are designed for states in which all nuclear material is safeguarded and which have undertaken a comprehensive commitment not to receive, manufacture or otherwise acquire nuclear weapons. The FMCT is designed to proscribe production of fissile material for nuclear weapons or other nuclear explosive devices by states that already have or may have nuclear weapons; thus, not all nuclear material would need to be subject to safeguards in the NWS and the TS.

The rationale for applying less than comprehensive safeguards under a FMCT can be summarized as follows:

- the existence in the NWS and TS of unsafeguarded stocks, produced prior to entry into force, which rules out fully comprehensive safeguards;
- practicalities:
  - the cost in absolute terms — inspection resources would have to be increased at least threefold relative to current IAEA levels to apply comprehensive safeguards;
  - cost-effectiveness (the cost in terms of strategic benefit gained) — does a comprehensive

approach yield significant additional benefits in proportion to the extra cost over a focussed approach?

— the need to keep the inspectorate to a manageable size.

At the other end of the spectrum to a comprehensive verification regime, some have proposed that the scope of the FMCT should be limited to weapon-grade material. The proponents consider this would be the most cost-effective approach. It is not clear however that significantly fewer inspections would be needed at enrichment and reprocessing plants to determine that there had been no production of weapon-grade material, relative to verification of production of "weapon-useable" material (discussed below). More importantly, it is of major concern that such a limited scope would undermine the critical purpose of the FMCT and undercut long-standing international standards in safeguards. The barriers to possible breakout would be substantially reduced because of the possibility of rapid upgrading of weapon-useable material to weapon-grade, or even the use of such material in sub-optimal nuclear explosive devices.

We envisage a verification regime primarily aimed at direct-use materials, i.e. those materials that are considered for IAEA safeguards purposes to be weapon-useable. Such material includes:

- plutonium with an isotopic concentration of Pu-238 of less than 80%;
- highly enriched uranium (HEU), i.e. containing 20% or more of the isotope U-235; and
- U-233.

These materials would be defined as "fissile materials" for FMCT purposes. We further envisage that these materials would be subject to verification only while they are in unirradiated form. This is based on the definition we believe is appropriate for "production", i.e. enrichment and reprocessing. Production of plutonium through irradiation in a reactor should not be included, as such plutonium would be available for weapon use only after reprocessing.

Some authors suggest that verification should be limited to separated direct-use material. The difficulty is what is meant by "separated". This could be seen as excluding fissile material, which has been blended for fuel fabrication, e.g. plutonium in MOX (mixed oxide fuel, a plutonium/uranium mix). For this reason we consider it is preferable to refer to unirradiated material.

Our definition excludes low enriched uranium (LEU), and also plutonium, HEU and U-233 in irradiated material (e.g. spent fuel or irradiated targets) or active waste. It will be important, however, to incorporate an appropriate definition of irradiated material so that material that is only lightly irradiated, or where radiation levels have significantly declined over time, will be subject to verification.

While some might consider that our definition of the material subject to a FMCT is narrow, it should be noted that it captures all fissile material produced after entry into force through enrichment and reprocessing and follows it up to the point of termination of safeguards:

- upon irradiation of the fissile material in a nuclear reactor or other intense neutron source to a level to be specified;
- upon blending of HEU or U-233 with depleted, natural or low enriched uranium so that the resulting uranium no longer meets the definition of fissile material (e.g., contains less than 20% of the isotope U-235); or
- upon determination by the verification agency that the fissile material has become practicably irrecoverable.

What Nuclear Facilities Would Be Covered By Verification?

The FMCT must provide for means to verify that fissile material is not produced outside international safeguards after entry into force, and that safeguarded fissile material is not diverted for use in nuclear weapons or other nuclear explosive devices, or for purposes unknown. The basic question is whether to seek a treaty with wide or with focused verification. A treaty of wide scope would cover all nuclear facilities and material, except for pre-existing stocks and materials related to non-proscribed military activities, while a focused treaty would concentrate on only the most proliferation-sensitive fissile material production facilities, i.e. reprocessing and enrichment facilities, and relevant product from those facilities. Clearly the issues here are very similar to those discussed in the section above.

A treaty of wide scope would cover all nuclear facilities and material, except for pre-existing stocks and materials related to non-proscribed military activities, while a focused treaty would concentrate on only the most proliferation-sensitive fissile material production facilities, i.e. reprocessing and enrichment facilities, and relevant product from those facilities.

Due to resource constraints affecting the IAEA, it is apparent that the only feasible approach to safeguards implementation under the FMCT is a focussed approach, under which safeguards would apply to:

- all unirradiated fissile material produced after entry into force in both peaceful and non-proscribed military activities;
- all facilities that are (or have been or could be) capable of producing these materials (primarily enrichment and reprocessing facilities), including decommissioned, shut-down and future facilities; and
- other downstream facilities handling (storage, processing, utilization and disposal) fissile material produced after entry into force up to the point of termination of safeguards.

Under the focussed approach all reprocessing and enrichment facilities would have to be declared and become subject to international verification or monitoring, regardless of their status or capacity. Although LEU would not be subject to the FMCT, all uranium enrichment activities would be subject to verification to provide assurance there is no undeclared production of HEU. It still remains to be determined what types of hot cells and R&D isotope separation facilities would have to be declared and monitored under the FMCT.

The "starting point" of safeguards under the FMCT should, in our opinion, be different from that of the comprehensive safeguards applied to NNWS under the NPT. We propose that the fissile materials defined above would become subject to verification under the FMCT when:

- plutonium, HEU or U-233 contained in irradiated material (fuel assemblies or targets) is introduced into a reprocessing plant or any other facility capable of separating subject material from fission products;
- plutonium, HEU or U-233 contained in active waste is introduced into any facility capable of recovering and partitioning these materials from fission products;
- any uranium is introduced into a uranium enrichment plant or any other facility capable of uranium isotope separation; or
- any plutonium is introduced into any facility capable of plutonium isotope separation (a separate issue is whether plutonium enrichment, which is primarily of military interest, should be proscribed).

What Other Facilities Would Have To Be Declared To The Verification Agency?

Verification arrangements under the FMCT must allow timely detection of undeclared production of fissile material. This implies that, in addition to the verification arrangements for the types of facilities listed above, the FMCT might require state declarations in relation to:

- stocks of fissile material existing at entry into force and retained outside international safeguards;
- nuclear facilities involved in non-proscribed military activities, for example:
  - — production of fissile material for non-explosive military uses, including HEU for naval propulsion; and
  - — activities relating to the use, reuse and recycling of fissile material already in the military cycle at entry into force.

It is not realistic to require declarations by states detailing all their nuclear activities, including military activities. It is likely that a requirement to provide detailed declarations covering military activities would not be acceptable to the NWS. It is highly unlikely that the TS would be willing to reveal military nuclear activities due to the ambiguity of their nuclear status.

In our view, although no detailed information should be required on military facilities involved in activities that are not proscribed by the FMCT, where those facilities and locations contain fissile material not subject to the FMCT they should at least be listed in state declarations with a short description of their purpose (though not detailing fissile material inventories).

As regards the verification agency's right of inspection or access at any location where there is evidence warranting investigation, we think that what constitutes evidence requires careful review, since the objective is to detect undeclared production, not undeclared material. An effective managed access regime, which takes account of the need to prevent compromising states' national security or proliferation-sensitive information, will be critical to the success of the treaty.

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Declarations and other transparency measures might be a useful complement to routine and other inspections. They might provide a means to enhance confidence at those facilities outside a routine inspection regime or at which traditional safeguards approaches have to be modified for use in NWS/TS. In some instances, it may be necessary to have transparency measures on the basis of bilateral or multilateral agreements between and among the NWS/TS.

How Close Need Verification Arrangements Under The FMCT Be To Those Under The NPT?

Verification arrangements for the FMCT do not have to be copied from those existing under the NPT due to the fundamental difference between the two treaties. There is no consensus as yet on the applicability in the NWS/TS of the new measures developed by the IAEA for the Strengthened Safeguards System (SSS).

The essence of our approach can be outlined as follows. On one hand, in the future when the SSS proves effective in providing sufficient assurance of the absence of undeclared enrichment and reprocessing activities, there can be a significant reduction in comprehensive safeguards measures in NNWS on natural uranium, LEU and plutonium in spent fuel. "Classical" safeguards measures would be necessary mainly on material that could be broadly classed weapon-useable, i.e. HEU and unirradiated plutonium. In other words, focussed safeguards would become the appropriate model for general application. Under this line of reasoning, over time a convergence can be expected between the current safeguards regime and the measures that are likely to be introduced for a FMCT. On the other hand, however, this situation does not yet exist, as the basic precondition — that the SSS will provide the necessary assurance of the absence of undeclared activities — has yet to be established. Thus for the immediate future it will be necessary to maintain at least some elements of classical safeguards at all types of facilities in NNWS.

Deriving assurance of the absence of undeclared facilities of particular types, such as enrichment and reprocessing facilities, will be as important under a FMCT as it is under NPT safeguards. While a NWS or TS having opted to join the FMCT might have a relatively limited incentive to produce undeclared fissile material, the possibility cannot be excluded altogether, and it would be important for the FMCT to provide assurance in this regard. So we consider that classical safeguards measures applied to relevant facilities under the FMCT regime will have to be complemented by appropriate measures along the lines of those provided for in the recently concluded Model Safeguards Protocol.

The FMCT
and Cuts in Fissile Material Stockpiles

Frank N. VON HIPPEL

In December 1993, the United Nations General Assembly adopted, by consensus, a resolution calling for negotiation of a "non-discriminatory, multilateral and international effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices."[1] In March 1995, the Geneva-based Conference on Disarmament (CD) agreed to a mandate to begin negotiations on a Fissile Material Cut-off Treaty (FMCT). After several additional years of dispute over their scope and linkage with disarmament, it appears that negotiations on a FMCT may finally begin in 1999. Since no nuclear weapon can be made without using at least kilogram quantities of fissile material,[2] a verified ban on new production would make up a major portion of the regime required to monitor irreversible nuclear disarmament.

The most fundamental issues that will have to be negotiated at the CD concern how a FMCT will relate to:

- pre-existing stocks of military fissile materials in the nuclear-weapons states (NWS);
- extension into the NWS of the international safeguards regime that monitors civilian nuclear activities in non-nuclear-weapon states (NNWS) parties to the Non-Proliferation Treaty (NPT); and
- the separation and stockpiling by some countries of huge quantities of directly weapon-usable plutonium for non-weapon purposes.

In brief, the approach proposed here supports a FMCT with comprehensive safeguards on civilian nuclear facilities in all states, complemented by separate commitments from the states with the largest stockpiles of direct weapon-usable materials — civilian as well as military — to greatly reduce these stocks.

Pre-existing Stocks of Military Fissile Materials

The United States and the Russian Federation, which have the largest stockpiles, should declare their sizes and commit to reducing their total stocks of separated plutonium to levels commensurate with the warhead levels to which they have agreed for START III. Similar cuts should be made in their stocks of highly enriched uranium (HEU, uranium enriched to more than 20% U-235), although

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the situation there is complicated by stockpiles reserved for naval-reactor use.

International Monitoring

As a first step, the NWS should declare those facilities which contain fissile materials. An agreement should then be made to extend the IAEA's international safeguards regime into the NWS step-by-step until the same coverage of their civilian nuclear sectors is achieved as in NNWS. Thereafter, nuclear weapons reductions should be accompanied by transfers of fissile materials and nuclear facilities out of the exempted military nuclear sectors into the inspected sectors.

Civilian Separation of Plutonium

The goal should be to phase out the civilian separation of plutonium, which no longer has any economic rationale. In the interim, states with civilian plutonium activities should commit to disposing of all but minimal working stocks of separated plutonium.

Military Fissile Materials

None of the "P-5"[3] nations is currently thought to be producing fissile materials for nuclear weapons. Indeed, all but China have publicly announced that they have permanently ended their production of fissile materials for weapons. The "Group of 21" (G-21) non-aligned countries at the CD[4] and some other states would therefore like to see the FMCT negotiations push the P-5 to make further steps toward nuclear disarmament by requiring at least very deep cuts in their existing stocks of weapons materials. In the words of the Indonesian ambassador to the CD, "brushing aside the issue of stockpiles, would, once again, render the cut-off treaty a mere non-proliferation measure ...".[5]

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The 1995 Shannon Mandate for the FMCT negotiations recognizes this widespread interest in stockpile reductions and "does not preclude any delegation from raising for consideration of the *ad hoc* [negotiating] Committee ... past production ... and the management of such material ...".[6]

The P-5 nations insist that the most efficient route to nuclear reductions is through negotiations among themselves. Among the NWS, those with the smallest stockpiles insist that the United States and the Russian Federation must take the lead. The United States and the Russian Federation have, in fact, already declared excess significant quantities of HEU and plutonium. However, their stockpiles remaining after the reductions will still be huge (see Table 1). Thus, for example, the United States will retain about 47 tons of weapon-grade plutonium, virtually all in weapons or weapons components.[7]

Detailed information about American plutonium stocks is available because the United States has declared its total stockpile of plutonium, along with information concerning its past production and disposition. The United States has also been preparing to make a declaration of similar data about its HEU. The Russian Federation should make similar declarations and the two countries should exchange additional information and undertake joint "nuclear archaeology" projects to increase each other's confidence in their declarations of past fissile-material production and disposition activities. Having a better measure of each other's stockpiles should make both countries more willing to agree to further cuts. Other countries will have to join in these transparency measures in order for stockpile reductions to continue.

Under START II, the United States and the Russian Federation have agreed to limit their number of deployed strategic warheads to 3,000–3,500 each. However, according to the United States Natural Resources Defense Council (NRDC), even after full implementation of the treaty, the United States plans to keep a total of about 10,000 warheads plus approximately 5,000 "reserve pits" that could be reassembled into an additional 5,000 warheads.[8] Judging from Table 1, the Russian Federation appears to be keeping at least as much weapons material.

Table 1. Stockpiles of directly weapon-usable fissile materials in 1996 in metric tons

When not otherwise indicated, the source is David Albright, Frans Berkhout and William Walker, *Plutonium and Highly Enriched Uranium, 1996: World Inventories, Capabilities and Policies,* SIPRI/Oxford University Press, 1997.

1 Estimated 80% average enrichment.
2 All but 33 tons of this material is less than weapon-grade, i.e. less than 92% U-235.
3 *Plutonium: The First 50 Years*, Figure 3.
4 *Plutonium Disposition Statement* (Clinton-Yeltsin Summit, Moscow, 1 September 1998). The United States apparently added 14.5 tons fuel and reactor-grade plutonium to the 38.2 tons of weapon-grade plutonium previously declared excess.
5 Approximate amount committed for blending down to LEU and sale to the United States under the *Agreement Between the Government of the United States of America and the Government of the Russian Federation Concerning the Disposition of Highly Enriched Uranium Extracted from Nuclear Weapons*, 18 February 1993.
6 *Plutonium Disposition Statement,* ibid.
7 The Russian Federation's 1998 declaration to the IAEA under the *International Guidelines for the Management of Plutonium,* ibid., www.iaea.org/worldatom/infcirc/infcirc549/a9.pdf.
8 *Strategic Defense Review*, ibid. Enrichment level not specified.
9 *Strategic Defense Review,* ibid. Of the plutonium declared excess, 0.3 tons is weapon grade.
10 British Department of Trade and Industry, 2 June 1998. In addition, Britain was storing 6.1 tons of foreign separated plutonium. Declaration to the IAEA under the *International Guidelines for the Management of Plutonium,* ibid., INFCIRC549/add. 8/1.
11 Declaration to the IAEA under the *International Guidelines for the Management of Plutonium,* ibid., INFCIRC549/add5/1. France was also storing 33.6 tons of foreign separated plutonium.
12 Declaration to the IAEA under the *International Guidelines for the Management of Plutonium*, ibid., INFCIRC549/add. 7.

In their March 1997 Helsinki Summit Statement, Presidents Clinton and Yeltsin agreed that the objective of the START III negotiations will be to reduce the number of strategic nuclear weapons deployed by each country to 2,500 or less by the year 2007. The Russian Government would like to reduce this limit to 1,500 or less, since it may be forced by its currently severe economic constraints to cut its deployed strategic warheads down to fewer than 1,000.[9]

The United States National Academy of Sciences has used "as a planning figure" for plutonium disposition the estimate that an average American warhead contains four kilograms of plutonium. On this basis, the United States and the Russian Federation could each declare excess all but 15 tons of weapon-grade plutonium and still have enough left for a few thousand warheads plus R&D and buffer stocks.

The United States National Academy of Sciences has used "as a planning figure" for plutonium disposition the estimate that an average American warhead contains four kilograms of plutonium.[10] On this basis, the United States and the Russian Federation could each declare excess all but 15 tons of weapon-grade plutonium and still have enough left for a few thousand warheads plus R&D and buffer stocks. Judging again from Table 1, this would also leave each of them with a stockpile of military plutonium comparable to the combined total stockpiles of all the other NWS.

Fissile material declared excess to military needs should be placed under IAEA safeguards. At the April 1996 G-8 "Nuclear Safety and Security Summit" in Moscow, the United States and the Russian Federation, along with Britain and France, "pledged our support for efforts to ensure that all sensitive nuclear material (separated plutonium and highly enriched uranium) designated as not intended for use for meeting defence requirements is safely stored, protected and placed under IAEA safeguards ... as soon as it is practicable to do so."[11]

For the United States and the Russian Federation to go further and actually destroy these stocks might require additional, far-reaching actions. The United States might, for example, insist that the Russian Federation dispose of its large stockpile of reactor-grade plutonium (see below). Further reductions might also require the commitments of additional NWS to both stockpile transparency and reductions. Britain has already declared its stockpiles of military fissile materials and committed to reductions in its military plutonium stockpile.[12]

The situation with reductions in the HEU stockpiles is more complex because, in the case of the United States at least, they include very large stocks reserved for American and British naval-reactor fuel use, which amounts to a few tons per year.[13] The Russian Federation, with a smaller and less active nuclear navy, uses less HEU for this purpose but does use HEU to fuel tritium-production reactors.[14]

The United States and the Russian Federation should each declare the total stocks of HEU that they have set aside for military reactor use to facilitate judgements of when these stockpiles may become obstacles to further nuclear disarmament.

The alternative to maintaining large unsafeguarded stockpiles of HEU for military reactors would be to place them under IAEA safeguards and then remove the HEU from safeguards when needed. Even countries that have declared themselves NNWS under the NPT are permitted to withdraw material from safeguards to fuel military reactors.[15]

Extension of the International Safeguards Regime in the NWS

The FMCT verification proposal preferred by the United States has raised concern because it would apply much less stringent verification requirements to the civilian nuclear-energy sectors of the NWS than are required of states that have signed the NPT as NNWS. The consensus United

Nations resolution and the Shannon Mandate explicitly call for a "non-discriminatory" treaty.

The United States favours a verification regime focused narrowly on:

- uranium enrichment plants, to determine whether or not HEU is being produced;
- spent fuel "reprocessing" plants at which plutonium or other artificial fissile isotopes made by neutron absorption[16] can be separated from highly radioactive fission products; and
- fissile materials produced after the FMCT comes into force and the facilities in which these materials are present.

This regime would be supplemented by challenge inspections involving managed access to suspect sites. This will be termed the "narrow inspection option" below.

Safeguards in NNWS cover in addition all power and research reactors fuelled by natural and low enriched uranium (LEU), and facilities at which their fuel is produced or stored. In the absence of such coverage, some LEU could be diverted without detection to a small clandestine uranium-enrichment facility to be further enriched to HEU, or some spent LEU or natural uranium fuel could be diverted to a large hot cell where the plutonium could be separated out.

Following the discovery of the extent of Iraq's clandestine nuclear-weapons activities, the IAEA is requesting declarations of and is making spot inspections at facilities not currently involved in the nuclear fuel cycle, and of equipment and even components that could contribute to a fissile-material production programme. Monitoring is also being extended to include environmental sampling and radiation measurements at locations where activities involving fissile materials might have taken place, and to wide-area environmental sampling to detect such activities. An Additional Protocol (INFCIRC/540) authorizing such monitoring was approved by the IAEA Board of Governors in May 1997 and had been signed by thirty-two countries as of September 1998.[17]

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Environmental monitoring will have to be more discriminating in NWS than NNWS because of past and continuing releases from the processing in weapon-production facilities of large quantities of unsafeguarded military materials. This strengthens the case for monitoring the entire civilian fuel cycle in NWS.

Realistically, given the large number of facilities to which safeguards will have to be applied and the large number of expert personnel that will be required, international monitoring in the NWS will have to be implemented in stages. The narrow coverage favoured by the United States is an obvious first step. However, coverage should be expanded as quickly as practicable until it is as comprehensive *outside declared military nuclear facilities* as the coverage that has been accepted by the NNWS. Even declared military nuclear facilities will have to be eligible for challenge inspections to verify that they do not contain clandestine reprocessing or enrichment facilities. All facilities in the NNWS that have accepted the Additional Protocol are already subject to "managed-access" challenge inspections by the IAEA — as they are states parties to the Chemical Weapons Convention. Managed access arrangements allow inspected countries to provide information required by international inspection teams while protecting sensitive military or proprietary information.

One argument that has been made for the narrow inspection option is that, since it would only cover tens of facilities, it should be much less costly than NPT-type broad coverage of the civilian sectors of the NWS, which would require the monitoring of approximately 1,000 additional nuclear facilities worldwide. However, a large fraction of the facilities that would have to be safeguarded under the broad coverage are reactors fuelled by LEU. Such reactors require only about one hundredth as much inspection effort as large reprocessing facilities or uranium-plutonium "mixed-oxide" (MOX) fuel fabrication plants,[18] and even that level of effort is being reduced as the IAEA introduces remote monitoring of spent-fuel pools.[19] As a result, a 1995 IAEA comparison of the annual cost of "full verification of separated fissile material and facilities capable of producing such material" (i.e. the narrow inspection option) was $90 million, only one-third less than the estimate of $140 million per year for full safeguards on all civilian facilities in the NWS.[20]

A still low-cost version of the narrow option considered by the IAEA would verify only the inputs and outputs of reprocessing plants and MOX and HEU fuel-fabrication facilities. Its weakness is that it might not detect clandestine reprocessing or enrichment of undeclared feed materials, even at the covered facilities. However, it might make sense to have such limited monitoring at military reprocessing facilities in the course of shutdown, when the implementation of full in-process safeguards for a relatively short period would be extremely costly and time-consuming.

The safeguards operations budget of the IAEA in 1997 was $60 million.[21] It would be tripled to $200 million/year for the most costly comprehensive FMCT verification approach considered in the 1995 IAEA working paper. This $140 million increase would be tiny, however, in comparison with the operational cost savings realized by the NWS as a result of shutting down their fissile-material production complexes. From 1984 through 1993, the United States alone spent about $2 billion per year on plutonium production for weapons. From 1954 through 1963, before the United States ended the production of HEU for weapons and began shutting down many of its plutonium-production reactors, the annual American rate of expenditure for the production of fissile materials for weapons averaged about $7 billion.[22]

Approximately one-half of the estimated additional safeguards burden under the comprehensive verification option would be from reprocessing and the associated plutonium recycling and storage activities.[23] This cost would therefore be saved if these activities are phased out, as recommended below.

The Problem of Large Civilian Inventories of Plutonium

The very large existing and proposed civilian programmes under which reactor-grade plutonium is being separated and stockpiled will inevitably become an issue in negotiations over a FMCT and over reduction of the stocks of military fissile materials. Twenty-five years ago, India's 1974 nuclear test demonstrated that a nominally civilian programme can be used as a cover for the production of plutonium for nuclear weapons.

The fact that most civilian plutonium is reactor grade rather than weapon grade provides small comfort.[24] According to American weapons experts: "At the lowest level of sophistication, a potential proliferating state or sub-national group using designs and technologies no more sophisticated than those used in first-generation nuclear weapons [e.g. the Nagasaki bomb] could build nuclear weapons from reactor-grade plutonium that would have an assured reliable yield of one or a few kilotons (and probable yield significantly higher than that). At the other end of the spectrum, advanced NWS such as the United States and the Russian Federation, using modern designs, could produce weapons from reactor-grade plutonium having reliable explosive yields, weight, and other characteristics generally comparable to those of weapons made from weapon-grade plutonium...".[25]

As already noted, the Russian Federation's large stockpile of reactor-grade plutonium may become a consideration in the willingness of the United States to further reduce its stockpile of weapon-grade plutonium. If the United States raises this issue, the Russian Federation may point to the very large stocks of reactor-grade plutonium in Britain and France. Similarly, China may not be willing to reduce its stockpile of military fissile material if Japan continues to maintain a very large stockpile of separated reactor-grade plutonium. Pakistan may not be willing to join in a FMCT if India continues to build up a large stockpile of separated plutonium for its breeder-reactor programme. These concerns provide one more reason why countries with very large stockpiles of separated reactor-grade plutonium should dispose of them as quickly as possible.

Recently, the Royal Society considered the problem of Britain's growing national stockpile of reactor-grade plutonium, which is expected to exceed 100 metric tons by 2010.[26] Its report found this stockpile to be a "radio-toxicity and proliferation risk" and that "the chance that the stocks of plutonium might, at some stage, be accessed for illicit weapons production is of extreme concern." It therefore urged the British Government to examine various options for disposing of the stockpile, suggesting specifically "that steps could be taken to reduce the amount added to it each year, primarily by reducing the amount of reprocessing carried out."

In fact, the end of the era of large-scale commercial reprocessing may be in sight. France and Britain, which together account for about 90% of global commercial plutonium separation (about 20 tons per year) are rapidly losing their customers. Most of their smaller reprocessing customers (Belgium, Spain, Sweden and Switzerland) have already opted for the less costly alternative of interim spent fuel storage.[27] Italy has abandoned nuclear power altogether and the Netherlands plans to do so by 2004.[28]

And now Germany and Japan, the principal foreign reprocessing customers of France and Britain (see Table 2), are also beginning to opt for storage over reprocessing. The new German Government has decided to encourage at-reactor storage of spent fuel until shutdown — thereby completing the reversal of the original German policy, which required reprocessing.[29] Japan's nuclear utilities have also begun to build more on-site storage rather than enter into new reprocessing contracts with the French or British reprocessors or complete their own very costly reprocessing plant.[30] In an era of electric power deregulation and increased price competition, the British and French nuclear utilities are likely to follow suit.

Table 2. Oxide fuel reprocessing contracts as of 1995 in metric tons heavy metal

Source: *Plutonium and Highly Enriched Uranium 1996*, ibid., pp. 162, 168.
[1] Not including fuel that had been reprocessed as of the end of 1993.

Work on the construction of a huge commercial reprocessing facility near the Russian military "plutonium city" of Krasnoyarsk-26 was halted by lack of funds in 1990.[31] Russia's Ministry of Atomic Energy (MinAtom) continues to operate the relatively small "Mayak" commercial reprocessing facility at a second closed city, Chelyabinsk-65, separating 1–2 tons of plutonium a year out of Hungarian, Bulgarian, Slovenian, Ukrainian and Russian spent fuel.[32] However, three previous customers (the Czech and Slovak Republics and Finland) have switched to interim storage; Ukraine plans to do so;[33] Hungary, currently the Russian Federation's most profitable reprocessing customer, has built an interim spent-fuel storage facility; and Bulgaria is finding its shipments of spent fuel to the Russian Federation facing increasing political opposition in the region.

India has a civilian reprocessing programme to provide plutonium for a planned prototype breeder reactor that is unlikely to be built.[34] The United States, Germany, Britain and France each spent billions of dollars on major breeder reactors demonstrating commercial applications during the 1970s and later. However, after concluding that such reactors would not be economical for the foreseeable future, they all abandoned or postponed these programmes.

To seek an immediate ban on commercial reprocessing as a part of a FMCT would doom near-term progress because France, Britain, the Russian Federation and India would all adamantly oppose any such broadening. States with civilian plutonium activities should be pressed, however, to at least dispose of all but minimum working stocks of separated plutonium. This was one of the original objectives of the Vienna-based negotiations of international "Guidelines for the Management of Plutonium". Unfortunately, these negotiations yielded only a vaguely worded, lowest common denominator commitment to "the importance of balancing supply and demand, including demand for reasonable working stocks for nuclear operations, as soon as practical."[35] Stronger commitments should be sought.

Notes

1. *Prohibition of the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices*, United Nations General Assembly resolution 48/75L.
2. Fissile material can sustain an explosive fission chain reaction. The fissile materials known to have been used in weapons are plutonium and natural uranium enriched to more than 20% in the chain-reacting isotope U-235. In addition to plutonium, however, other artificial fissile isotopes, such as U-233, can be made by neutron capture in "fertile" natural material.
3. The United Kingdom, China, France, the Russian Federation and the United States, the five permanent members of the Security Council, are also the only countries recognized as NWS in the NPT.
4. The G-21 (originally twenty-one and now thirty countries) are members of both the CD and the "Non-Aligned Movement", countries not allied with either the United States or the Soviet Union during their Cold War.
5. Agus Tarmidzi, Indonesian Ambassador to the CD, Geneva, 20 February 1997, CD/PV.756.
6. *Report of Ambassador Gerald E. Shannon of Canada on Consultations on the Most Appropriate Arrangement to Negotiate a Treaty Banning the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices*, CD/1299, 24 March 1995.
7. As of September 1994, 66.1 tons of American plutonium were either in weapons or in the "pits" of dismantled weapons stored at the Department of Energy's Pantex site (*Plutonium: The First 50 Years,* United States Department of Energy, DOE/DP-0137, February 1996, Figure 4). Out of a total of 38.2 tons of weapon-grade plutonium declared excess, 21.3 tons to be stored in Pantex in pits had been declared excess (*Fact Sheets* released at the Department of Energy's Openness Press Conference, 6 February 1996). The difference is 44.8 tons. Since the United States is retaining 47 tons of weapon-grade plutonium, this leaves approximately 2 tons of weapon-grade plutonium for R&D and working stocks.
8. Robert S. Norris and William M. Arkin, U.S. Nuclear Stockpile, *Bulletin of the Atomic Scientists*, July/August 1998, pp. 69–71. According to this report, in addition to 3,500 deployed strategic warheads, the United States plans to keep approximately 1,000 non-strategic warheads, 500 spares, 2,500 "hedge" warheads that could be re-deployed

on strategic missiles and bombers, and 3,000 “inactive-reserve” warheads.
9. David Hoffman, Troubles Invigorate Debate on Start II: Russian Crisis Saps Budget for Missiles, *Washington Post*, 19 November 1998.
10. *Management and Disposition of Excess Weapons Plutonium*, National Academy Press, 1994, p. 40.
11. *Moscow Nuclear Safety and Security Summit Declaration*, 20 April 1996.
12. *Strategic Defense Review,* United Kingdom, July 1998, www.mod.uk/policy/sdr.htm.
13. In the early 1980s, the United States was buying about 5 tons of weapon-grade uranium per year for naval reactors (T.B. Cochran, W.M. Arkin, R.S. Norris and M.M. Hoenig, *U.S. Nuclear Warhead Production*, Ballinger, 1987, p. 71). Since that time, the number of American nuclear-powered ships has declined significantly.
14. The Russian Federation uses a range of HEU enrichments in naval and ice-breaker reactor fuel. Bukharin estimates that Russian fuel use for these purposes is equivalent to about 0.4 tons of weapon-grade uranium per year. He also estimates a consumption of 1.5 tons of 90% HEU per year by two 1,000 MW (thermal) tritium-production reactors operating at an average 60% capacity factor and 30% U-235 burn-up (Oleg Bukharin, Securing Russia’s HEU Stocks, *Science & Global Security 7*, 1998, pp. 311–33). However, this tritium-production capacity was sized to support a Soviet nuclear arsenal containing 30,000–40,000 warheads. The future HEU demands of Russian tritium-production reactors will therefore be much lower. The United States plans to use a power reactor fuelled by LEU to produce its weapons tritium. Neither country will need to produce tritium if the size of their warhead stockpiles continues to decline faster than the 5.5% annual decay rate of tritium.
15. Article 14 of INFCIRC/153, the safeguards agreement between the IAEA and countries that have declared themselves NNWS under the NPT.
16. “Plutonium” will hereafter be used as a shorthand to refer to all artificial fissile isotopes that would be subject to the FMCT. Today, significant quantities of artificial fissile materials are made only by use of nuclear reactors. In the future, this might also be possible using neutrons produced with high-current particle accelerators.
17. *IAEA News Briefs,* October/November 1998.
18. According to guidance provided by *IAEA Safeguards Implementation at Nuclear Fuel Cycle Facilities* (IAEA, 1985), a reprocessing plant separating 1–2 tons of plutonium per year would require 850 person-days of inspection (PDI) effort. This level of effort might be doubled for large reprocessing plants such as those operated by Britain and France, whose design outputs are about 6 and 13 tons of plutonium per year respectively. The level of inspection effort for a MOX plant might be up to 600 PDI/year. By contrast, the expected level of effort at a light-water reactor fuelled with LEU was estimated at about 15 PDI.
19. Safeguards at Light-Water Reactors: Current Practices, Future Directions, *IAEA Bulletin,* 4/1996, pp. 16–19.
20. *A Cut-off Treaty and Associated Costs*, IAEA Secretariat working paper presented at the Workshop on a Cut-Off Treaty, Toronto, Canada, 17–18 January 1995. “This paper has not been updated. The assumptions on which the paper was based have to some extent changed ... No detailed consideration was given at the time to the Euratom factor [i.e. the fact that British and French civilian nuclear facilities are already under Euratom safeguards]. So neither the arrangements under the New Partnership approach [the use of remote monitoring and other arrangements to reduce the need for on-site inspections at reactors], nor earlier arrangements have been factored in [the fact that some facilities in the NWS are already under IAEA safeguards due to “voluntary offers” and tri-lateral or other arrangements]...” (personal communication, Piet de Klerk, Director, Office of External Relations and Policy Coordination, IAEA, 1 December 1998).
21. IAEA, *Annual Report for 1997*, p. 49.
22. *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons Since 1940,* Stephen I. Schwartz (ed.), Brookings Institution Press, 1998, pp. 560–61 (in 1996 dollars).
23. Chemical reprocessing (34%), MOX- and HEU-fuel fabrication (10%), Pu and HEU conversion (5%), and Pu and HEU storage (3%) (*A Cut-off Treaty and Associated Costs*, ibid.).
24. Weapon-grade plutonium contains less than 7% Pu-240. Reactor-grade plutonium contains more than 18%.
25. *Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives,* United States Department of Energy report DoE/NN-0007, January 1997, pp. 38–39.
26. *Management of Separated Plutonium,* British Royal Society, February 1998.
27. *Nukem Market Report*, February 1998; Belgium Cancels 1991 Reprocessing Contract, Postpones Debate on MOX, *Nuclear Fuel*, 14 December 1998, pp. 16–17.
28. *Nukem Market Report,* October 1998, p. 9.
29. *Nuclear Fuel*, 2 November 1998, pp. 3–4.
30. Rokkasho Completion Delay Might Extend Until 2007, *Nuclear Fuel*, 23 February 1998, p. 9; Plans for Central Intermediate Storage Facilities for Spent Nuclear Fuel, *Nuke Info Tokyo*, May/June 1998, p. 4.
31. MinAtom Ends Plan to Reprocess at Krasnoyarsk, Will Upgrade Mayak, *Nuclear Fuel,* 2 November 1998, p. 5.
32. MinAtom Seeks to Revive Foreign Reprocessing Contracts for RT-1, *Nuclear Fuel*, 30 June 1997, p. 7.
33. Ukraine Wants EC Cooperation Pact to Add Value to Ziconium, Uranium, *Nuclear Fuel*, 5 October 1998, p. 9.

34. Despite Chronic Delays, DAE [Department of Atomic Energy] Maintains Prototype Breeder to be Built Soon, *Nuclear Fuel*, 1 December 1997, p. 9.
35. *Guidelines for the Management of Plutonium* signed by Belgium, China, France, Germany, Japan, the Russian Federation, Switzerland, the United Kingdom and the United States, and deposited with the IAEA, 1 December 1997. India was not invited to participate in these discussions because it is not a party to the NPT.

Verification of a Fissile Material Cut-Off Treaty

Annette Schaper

The potential benefits of a Fissile Material Cut-off Treaty (FMCT) are well known: it will put non-proliferation obligations on states outside the Non-Proliferation Treaty (NPT); it will reduce discrimination within the non-proliferation regime; it will introduce verification measures in states that are not currently subjected to full-scope safeguards, e.g. nuclear-weapon states (NWS) and states outside the NPT (SON), thereby further reducing proliferation dangers; and it will give a push to other initiatives aimed at similar goals, especially international collaboration on the security of fissile materials and nuclear disarmament.

While the benefits are clear and indisputable, there is less concordance on the shape that a FMCT verification regime will take. Many verification scenarios are possible, ranging from just a fence around former military production facilities to completely new global concepts. Verification must cover not only non-production but also non-diversion of (at least) civilian materials produced after entry into force. No material must be diverted for use in nuclear weapons, a commitment to be undertaken equally by all signatories of a FMCT. This is already being verified in non-nuclear-weapon states (NNWS) under full-scope safeguards. The difference under a FMCT verification regime would be that NNWS would not be allowed to possess unsafeguarded materials from earlier production, while NWS and SON would be allowed a "black box" of previously excluded materials.

It is not clear whether the scope of the treaty will cover only the future production of weapon-usable materials or if it will also include previously produced materials. Even if the scope is very limited, e.g. only a ban on future production, it must be ensured that material produced in the future is not falsely declared as earlier production. If civilian material were to be left out, it could eventually be declared as earlier production and diverted to military use. Therefore, all civilian and military materials produced after entry into force would need to be put under safeguards.

But why should the NPT and the FMCT have different verification standards when their verification tasks are almost the same? It can be argued that as long as a NWS has not disarmed down to zero, some warheads more or less do not make much difference. Additionally, as long as the black boxes of the NWS are not empty, it makes less of a difference if small diversions go undetected. However, the goal of verification is the deterrence of non-compliance through creation of a sufficiently high detection risk. Even in NNWS, there will always remain a low probability that non-compliance could remain undetected, and this probability is determined by a balance between trust and technical verification efforts and costs. The higher the trust, the lower the detection probability that can be tolerated. In relation to the NPT, the trust among the NNWS is not high

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In relation to the NPT, the trust among the NNWS is not high enough for them to renounce full-scope safeguards or to lower standards. With this in mind, why should NWS be more trusted not to divert fissile materials for nuclear explosive purposes than NNWS?

enough for them to renounce full-scope safeguards or to lower standards. With this in mind, why should NWS be more trusted not to divert fissile materials for nuclear explosive purposes than NNWS? A provocative variant of this question is: who can be more trusted, those who have renounced nuclear weapons or those who continue to maintain nuclear arsenals and huge quantities of unsafeguarded weapon materials? This is not just a question of technical feasibility but, more principally, of the importance of treaty compliance. A FMCT would be discriminatory if there were two different classes of states parties who were granted two different degrees of trust. But we should keep in mind that the current non-proliferation regime is discriminatory, and the reduction of discrimination can only be achieved in steps, not all at once.

The NWS have difficulty accepting full-scope safeguards on their entire civilian and converted fuel cycles for several reasons. Firstly, conservative inertia drives decision-makers towards viewing nuclear policies as exclusively national matters. Accepting full-scope safeguards is therefore a severe blow to national sovereignty. Secondly, installing a verification system is indeed a technical challenge.[1] Most production plants in NWS, especially from the early years, were not designed with safeguards. Neither did bookkeeping have the same priority as in NNWS because there was never the need for international justification. It is much more difficult to implement verification post-construction than at the time a facility is designed and built. Therefore, it is not surprising that many analysts from NWS envisage a progressive, step-by-step approach to verification.[2]

South Africa is the only case in history where a state possessing nuclear weapons converted to a NNWS and implemented comprehensive safeguards. The safeguards implementation was a success, but it also revealed technical challenges different than those known from previous safeguarding efforts.[3] As a second example, Britain brought a large reprocessing plant (B205) under Euratom safeguards some twenty years after it was designed. Although the safeguards applied there might not meet IAEA criteria, Euratom is satisfied that it can verify non-diversion from the plant. An interesting future study would be on how the United Kingdom brought B205 under safeguards.[4]

The Nuclear Fuel Cycle and Existing Safeguards

IAEA safeguards are a verification system within nuclear non-proliferation policy, the NPT and the Treaty of Tlatelolco to ensure that no nuclear material is diverted for use in nuclear weapons or other nuclear explosive devices. A state aiming at clandestine acquisition of direct-use nuclear material has several procurement strategies:[5]

- reusing already shut-down facilities;
- pursuing additional undeclared operations in operating declared facilities;
- diverting materials from declared inventories; or
- using clandestine undeclared production facilities.

Safeguards must be designed in a way that they are capable of detecting any of these operations with a sufficient probability. The basic objective of INFCIRC/153-type safeguards (those verifying the compliance of NNWS with the NPT) was "the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or for other nuclear explosive devices or for purposes unknown",[6] i.e. the third procurement strategy.

Feed material (e.g. natural, depleted or low enriched uranium) and an enrichment facility are necessary to produce highly enriched uranium (HEU). Spent fuel and reprocessing technology are required for plutonium production. Therefore, the most proliferation relevant elements of the nuclear fuel cycle are enrichment and reprocessing. However, safeguarding only enrichment and reprocessing would leave too many loopholes, and therefore full-scope safeguards cover not only plutonium and HEU production facilities but also all other elements of the nuclear fuel cycle and nuclear reactors without exception — the respective intrusiveness depending on the technical hurdles to acquire direct-use material. In contrast, INFCIRC/66-type safeguards were designed to apply to individual shipments of plants and materials to SON. At a facility, the two types of safeguards often consist of similar control measures. However, large loopholes remain as long as the underlying verification approach does not cover systematically the entire fuel cycle. Safeguards agreements between NWS and the IAEA apply only to individual facilities, and there is always the legal possibility for a NWS to withdraw a facility from controls.

The number of facilities in NWS currently subjected to voluntary IAEA safeguards is small for three reasons:

- limited funds;
- not much sense had been seen in verifying non-diversion in states that are legally allowed to produce undeclared and military nuclear materials; and
- in these states, the assumption still prevails that their nuclear production is only a matter of national, not international, concern.

The obligation of NNWS to not divert nuclear materials for weapon purposes is already being verified by the IAEA. The agreements between the IAEA and the inspected state are based on a model agreement, INFCIRC/153.[7] It sets the principal requirements for full-scope safeguards. Full-scope safeguards are applied in all nuclear facilities, including normal power reactors. Yet recent experiences in Iraq, a NNWS according to the NPT, have demonstrated that even this is unsatisfactory. Iraq's proliferation has demonstrated that the objective of only detecting fissile material diversion is not enough, and has led to more emphasis on the additional goal of detecting clandestine acquisition activities. This has resulted in the IAEA's Strengthened Safeguards System (S^3), formerly called 93 + 2.

Iraq's proliferation has demonstrated that the objective of only detecting fissile material diversion is not enough, and has led to more emphasis on the additional goal of detecting clandestine acquisition activities. This has resulted in the IAEA's Strengthened Safeguards System (S^3), formerly called 93 + 2.

S^3 goes beyond previous safeguards, with the additional goal of detecting undeclared production and even preparation for production. S^3 detection methods depend on the task and include: seals; monitors; special activity surveillance; design verification; independent measurements of inventories; various material accountancy measures; ad hoc, routine and special inspections; environmental sampling; remote monitoring; and inspector deployment. Now both nuclear materials and non-nuclear elements of the fuel cycle and R&D are affected by control or reporting measures. These measures are aimed at both the receiving and supplying ends of the technology transfer chain. Table 1 gives an overview of the most important fuel cycle elements, their significance for the acquisition of direct-use material, and the current status of IAEA safeguards.

The principle of universality is an important prerequisite for the success of the S^3 reform. It is logical that a similar verification system would be appropriate and necessary for effective FMCT verification. The IAEA sees itself as the appropriate agency for the verification of a FMCT.[8]

Table 1. Overview of the most important nuclear fuel cycle elements, their proliferation relevance and IAEA safeguards

Control and Detection of Direct-Use Material Production

Although IAEA safeguards cover the whole nuclear fuel cycle and the author believes that the same should be done in a FMCT, a closer look specifically at the production of direct-use materials is useful. In all likelihood, the NWS will start the FMCT negotiations with the position of limiting verification to direct-use material production.

The specific technological requirements of verification depend on the characteristics of the technical production process. HEU is produced through enrichment and plutonium through reprocessing. While there are some specific differences, the two processes have a lot in common.[9] Both techniques process nuclear materials flowing through a succession of stages. Diversion could take place at many locations, and verification must be able to detect it. Both processes also leak detectable characteristic traces of nuclear isotopes. Verification that a facility which has been declared "shut down" is truly closed or detection of clandestine activities makes use of this fact.

Uranium

There are several methods of HEU production.[10] The most common technologies are gaseous diffusion and centrifuge enrichment. The former is the most common method in the United States, the latter in Europe. Other methods are aerodynamic enrichment, for example the jet nozzle and helicon processes that were used by South Africa, electromagnetic separation (EMIS) that has been used by Iraq, and chemical isotope separation, which has only reached the stage of pilot plants in France and Japan. A new enrichment technology expected to be applied commercially in a few years is atomic vapour laser isotope separation (AVLIS). A test facility is running in the United States, and France's efforts are in the development stage.[11] In South Africa, R&D on a similar technology, molecular isotope separation (MLIS), is underway in cooperation with the French company Cogema.[12] Another technical variation is chemical reaction by selective laser activation.

The basic safeguards approach for uranium is material accountancy that verifies the report of a national system, the so-called State's System of Accounting for and Control (SSAC) of nuclear material, supplemented by containment and surveillance techniques. Analyzing samples of the various material streams is another routine safeguards measure in enrichment plants. Measuring equipment is installed at various points to check the isotopic composition of the streams. In plants not originally subjected to safeguards, such as former military production plants and other civilian plants in NWS and in the SON, such equipment must be installed. S^3 has also implemented the option of taking environmental samples to ensure that no additional undeclared HEU production has occurred. However, this method works only in LEU facilities where HEU has never been produced, since it would cause false alarms in former military facilities that have been converted to LEU production.

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Noteworthy is the Hexapartite Enrichment Project (HSP), whereby six countries (Germany, Netherlands, Japan, the United States, the United Kingdom and Australia) agreed to place all civil centrifuge plants under permanent IAEA safeguards. Initiated in 1989, the HSP was concerned primarily with devising a safeguards strategy to cover the new gas centrifuge enrichment facilities that began springing up in Western Europe and Japan during the 1970s. This project also entailed the development of special verification techniques that enabled the implementation of satisfactory measures and an agreement between the IAEA and Euratom.[13] One interesting option would be to widen this agreement to include the Russian Federation and China.[14]

Plutonium[15]

Plutonium does not occur naturally, rather it is produced in nuclear reactors. Spent fuel contains plutonium, highly radioactive fission products and their decay products, and unaffected uranium. Plutonium can be separated from spent fuel by a chemical means called reprocessing. Similar to enrichment plants, the basic safeguards approach at reprocessing plans is material accountancy that verifies the report of the SSAC, supplemented by containment and surveillance techniques.[16] Flows are checked at predetermined locations known as "key measurement points", and samples can be taken from various other areas.

In NNWS, safeguards implementation is taken into account at the planning stage of a plant, and design verification can take place during construction. This makes it much more difficult to pursue a path of unmonitored diversion. Adding safeguards at a civilian reprocessing plant not formerly under safeguards is difficult but not impossible. The first step of safeguards implementation is a thorough design analysis and a reconstruction of operation history. Verification that shut-down facilities remain so is comparably easy through on-site inspections with the use of technical methods. An additional verification task is the detection of undeclared production facilities.

General Limits

Although verification never can be 100% certain, a large detection risk implies deterrence. It is enhanced by national technical means (NTM). For this reason, it is planned within S^3 to grant the IAEA greater access to intelligence information. In relation to a FMCT, NTM can be implemented independently from the IAEA, as in several other arms control treaties.

Reprocessing and enrichment do not only require plants but also spent fuel or feed uranium. Verification of a FMCT would be much more reliable if the other elements of the nuclear fuel cycle were included in a safeguards regime, as currently is the case in NNWS. For example, safeguarding spent fuel is far simpler than safeguarding a reprocessing plant, because it consists of discrete items that can be counted and verified with uncomplicated measurement methods.

Different Degrees of Intrusiveness and their Costs

The IAEA has worked out several potential FMCT verification scenarios.[17] The first is comprehensive safeguards similar to those in NNWS including the measures contained within the Additional Protocol (INFCIRC/540), because "verification arrangements to anything less than a State's entire fuel cycle could not give the same level of assurance" of compliance.[18] Only a black box of previously excluded materials would be left out. The second scenario constrains the technical objective of verification to the provision that all production facilities of direct-use material are either shut down or converted to civilian use and subject to safeguards. This scenario is subdivided into three alternatives with various degrees of intrusiveness and varying cost estimates. A substantial period of time would be required for the implementation of any one of these scenarios, with different timelines for different participants. A prerequisite would be that SSACs in the NWS and the SON meet international standards. However, these do not exist everywhere and need extra time and effort to be built up.

The total costs of a comprehensive verification system is estimated in the range of $140 million. The least intrusive alternative is estimated to cost about $40 million. This should be compared to the expenditure of $67.5 million by the IAEA's Department of Safeguards (1993 figure). Therefore the IAEA budget for safeguards must be about tripled in case of universal, full-scope safeguards. Sometimes NWS use the cost argument to oppose plans for universal coverage. On the other hand, the prospect of investing in safeguards may appeal to NWS, particularly because of the benefits that would accrue.[19] Judgements on costs are determined by priorities. For example, the United States has allocated several billion dollars for the maintenance of the Nevada test site in the context of negotiating and signing the CTBT, which far exceeds the amount the international community would annually spend on universal, full-scope safeguards.

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Specific Verification Challenges

Naval fuel

Reactors for naval propulsion are frequently fuelled with HEU because such reactor cores can be made especially small. Reactor fuel can be either military or civilian. NNWS are allowed to possess military HEU for non-explosive purposes without safeguards as long as it is not used for nuclear explosives, although this has not happened so far. In INFCIRC/153 (§14b), it is foreseen that verification of fuel is waived as long as the nuclear material is in a "non-proscribed military activity".

In case the scope of the FMCT covers only material produced after entry into force, it must be clarified whether or not unverified production of HEU or other fuel for military naval reactors will be banned. If allowed, the FMCT would contain an unacceptable loophole. It would be better to ban unverified HEU production altogether. This is likely to be agreeable to all participants because large stocks of HEU already exist that can be used as naval fuel. In case the scope of the FMCT requires placing all or some existing material under safeguards, special provisions must be found for naval fuel.

In principle, HEU is not always necessary for naval reactors because they can also be driven with LEU, similar to civilian research reactors. Because of proliferation concerns, most research reactors worldwide have been converted to non-weapon-usable fuel. It is likely that a similar conversion is also possible for submarines.

Tritium

Tritium is contained in all modern nuclear warheads. Since it does not occur in nature except in unretrievable traces, it must be produced artificially.[20] Its production gives rise to a difficulty because it might be confused with plutonium production. It is not possible to renounce the use of tritium for warheads, since this would require new warhead designs and the need for nuclear testing that is banned by the CTBT. Because tritium is a radioactive isotope of hydrogen with a half-life of about twelve years, nuclear disarmament does not abolish the need for new production, it only delays it. More precisely, each reduction of nuclear warheads by half would delay the need for new tritium for another twelve years.[21] A ban on military tritium production is therefore not acceptable to the NWS unless accompanied by comprehensive nuclear disarmament. Tritium is also used for several civilian applications, including scientific civilian fusion research. The wording of the FMCT negotiation mandate limits its scope to only fissile material, and excludes fusion material such as tritium.

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The most efficient and cost-effective tritium production method is by placing lithium in nuclear reactors. This procedure has been used by all NWS and it is the most probable method to be used in future. However, it is also the one that is the most likely to be mistaken for plutonium production. While exempting tritium production reactors from verification would weaken the treaty, a provision that allows states to withdraw military tritium production facilities is likely to be raised in negotiations. Again, this would create a big loophole. The IAEA agrees. Depending on whether or not naval fuel and tritium production facilities are placed under safeguards, the “level of assurance against the diversion of fissile material from amounts produced for such non-explosive uses permitted by the treaty could be high or low.”[22]

Dual-use and military facilities

There is some reluctance to submit military facilities to extremely intrusive verification because sensitive information could be revealed. Sensitive facilities include former military production sites, maintenance facilities still in use, or dismantlement facilities for nuclear warheads. While closed facilities do not pose problems for verification, verification in maintenance and dismantlement facilities is unlikely to be acceptable to NWS. Additionally, the SON probably have facilities that raise similar problems. Examples of sensitive information include the following:

- *The isotopic composition of nuclear materials.* The Russian Federation is especially reluctant to reveal the exact isotopic composition of its weapon-grade HEU or plutonium.[23] It cannot be excluded that inspections and measurements on former military sites could find traces of weapon materials, even if their source had been removed prior to the start of inspections.
- *The amount of material needed for a single warhead.* It is also possible that at such sites material pieces or tools could be found that reveal the size of nuclear weapon pits. Such information is still regarded as sensitive, even after the end of the Cold War. An urgent task at such a facility is therefore the removal of these parts and tools as soon as possible in order to prepare it for the start of safeguards. This work, if necessary, is urgent anyway in order to minimize proliferation dangers.
- *Warhead design information*. In case a fissile material production facility or storage site is co-located with a warhead factory, machinery for pit fabrication and conventional explosive ignition technology could be around. This is believed to be the case at some Russian facilities.

This kind of information is highly sensitive and therefore must be protected. An urgent task for the owning state is the physical separation of fissile material production, storage sites (at least those for future civilian material) and weapon manufacture sites, in order to prepare for future inspections. In case such different facilities are co-located very closely, special arrangements will be necessary to protect the sensitive areas. Also transport to and from such special buildings must be exempted.

Implementing MC&A and SSACs

As previously mentioned, most plants in the United States, the Russian Federation, China and in the SON were not designed with safeguards in mind. Therefore, infrastructure for the installation of control equipment might be lacking. Before a SSAC can work effectively, technical material control and accountancy (MC&A) at the facilities must be implemented. Improvements are necessary and underway independent of the cut-off, at least in the Russian Federation, in the context of the various international collaborative projects for the improvement of nuclear security. A similar though smaller effort was necessary for the implementation of full-scope safeguards in South Africa.

Steps that must be taken in order to create a SSAC that is compatible with IAEA standards include: implementing regulations containing technical, organizational and reporting requirements for MC&A; implementing the interaction between the MC&A in a facility and the SSAC; installing measurement systems at facilities; preparing the initial technical physical inventory and implementing the according regulations; training personnel; and moving from the old to the new system. There are many problems that must be overcome, both of a financial and an organizational nature. In most NWS and SON, different authorities are responsible for the control of the military and civilian nuclear cycles. These states might anticipate problems in the transition of material and facilities from military to civilian use. It is recommended that they collaborate to solve such challenges.

Time will be necessary after entry into force for implementation of verification. However, it is strongly encouraged that such time be specified. Vague treaty language, like "as soon as practicable", could delay success indefinitely. It would be advisable to negotiate a timetable for specific steps, perhaps combined with technical collaboration programmes among states, the IAEA, Euratom or other SSAC agencies.

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A Universal Verification System?

An effective and non-discriminatory FMCT will need universal, full-scope safeguards. However, there are several political and technical hurdles. Paving the way for universal acceptance within the NWS and SON is a political problem and will take time, implementing material accountancy systems in these countries is a technical problem and will take time and money, implementing the safeguards is also a technical problem and will take more time and even more money.

In the long term, it will be necessary to work on fundamental reforms, moving towards a universal system without distinction between NWS and NNWS. Such a future system will be different, characterized by a new safeguards culture based more on technical and political judgement than on the current ad hoc and often political arrangements. This reform will have to encompass several areas: finances, organization, decision-making, effectiveness, concern about non-compliance, as well as underlying principles. A reform will be necessary even without a FMCT because of the various non-proliferation and disarmament problems that need new solutions. Verification activities are already underway and more will come, starting with the implementation of S^3 and safeguards on declared excess weapon materials. A new global approach could potentially lay the basis for a future nuclear-weapon-free world. To quote William Walker, "the regulatory situation in all countries, including the NWS, should be approached *as if the world is preparing for total nuclear disarmament*, whether or not that is a desirable or realistic prospect".[24]

Notes

1. On the technical abilities of the IAEA to verify a cut-off see: T.E. Shea, *Verifying a Fissile Material Production Cut-Off: Safeguarding Reprocessing and Enrichment Plants*. Current and Future Practices, Seminar on Safeguards and Non-Proliferation, IAEA Headquarters, 16–17 November 1995.
2. "The burden of a comprehensive verification system might be mitigated if the intensity of safeguards in the declared NWS were relaxed somewhat from that applied in the NNWS." See F. Berkhout, O. Bukharin, H. Feiveson and M. Miller, A Cutoff in the Production of Fissile Material, *International Security*, Winter 1994/95 (vol. 19, no. 3), pp. 167–22, quotation on p. 183; S. Fetter and F. von Hippel, A Step-By Step Approach to a Global Fissile Materials Cutoff, *Arms Control Today*, October 1995, pp. 3–8.; Zhu Qiangguo, *A Cutoff of Fissile Material Production for Nuclear Weapon Purposes and Its Concerned Issues*, Paper presented at the 8th International Summer Symposium on Science and World Affairs, Beijing, China, 23–31 July 1996. Jin Huimin maintains that the objective of a FMCT is just to shut down military facilities, so verification of civilian activities has little to do with it. See Jin Huimin, *On Verification of the Cut-Off Treaty*, Paper for the 5th ISODARCO-Beijing Seminar on Arms Control, 11–16 November 1996, Cheng-Du, China.
3. S. Fetter, *Verifying Nuclear Disarmament*, Stimson Center, Occasional Paper No. 29, October 1996.
4. W. Walker, personal communication.
5. T.E. Shea, see note 1.
6. § 28 of INFCIRC/153 (Corrected), June 1972. For explanations of the terms timely detection, significant quantities, detection probability, and false alarm probability see *IAEA Safeguards Glossary*, 1987 edition.
7. European Union members have transferred the sovereignty of owning civilian nuclear materials including accountancy authority to Euratom. In this case, there is a safeguards agreement between Euratom and the IAEA (INFCIRC/193). For a description of IAEA safeguards see: D.A.V. Fischer, The International Atomic Energy Agency and Nuclear Safeguards, in: D. Howlett, J. Simpson (eds.), *Nuclear Non-Proliferation – A Reference Handbook*, Longman, Harlow, 1992.
8. This is also the expectation of the IAEA. See S. Thorstensen, *Fissile Material and Verification – IAEA Capability and Infrastructure for Verification of Fissile Material*, presentation at the Cut-Off Convention Workshop, Toronto, Canada, 17–18 January 1995.
9. T.E. Shea, see note 1.
10. A comprehensive overview on enrichment technologies and their significance for proliferation is A.S. Krass, P. Poskma, B. Elzen and W.A. Smit, *Uranium Enrichment and Nuclear Weapon Proliferation*, SIPRI, Taylor & Francis Ltd, London and New York, 1983.
11. A. MacLachlan, France 'on schedule' to show feasibility of SILVA in 1997, *Nuclear Fuel*, 11 March 1996.
12. A. MacLachlan, Cogema to help South Africa's AEC develop MLIS enrichment process, *Nuclear Fuel*, 11 March 1996.
13. D.A. Howlett, *Euratom and Nuclear Safeguards*, Macmillan, Southampton, 1990. See p. 225 ff.
14. W. Walker, personal communication.
15. On technical properties of plutonium see: *Nuclear Energy Agency, Plutonium Fuel – An Assessment*, OECD, Paris, 1989.
16. T.E. Shea, note 1; T.E. Shea et al., Safeguarding Reprocessing Plants: Principles, Past Experience, Current Practice and Future Trends, *Journal of Nuclear Materials Management*, July 1993; United States Congress, Office of Technology Assessment, *Nuclear Safeguards and the International Atomic Energy Agency*, Appendix A: Safeguarding Reprocessing Facilities, OTA-ISS-615, Washington, 1995.
17. IAEA, *A Cut-Off Treaty and Associated Costs – An IAEA Secretariat Working Paper on Different Alternatives for the Verification of a Fissile Material Production Cut-Off Treaty and Preliminary Cost Estimates Required for the Verification*

of these Alternatives, presented at the Cut-Off Convention Workshop, Toronto, Canada, 17–18 January 1995.

18. Ibid., p. 6.
19. F. McGoldrick (United States State Department) said in 1994: "Some argue that the benefits of safeguards in nuclear weapon states are not commensurate with the costs. I think they are, and many share this view." F. McGoldrick, *U.S. Fissile Material Initiatives – Implications for the IAEA,* invited paper, Proceedings of the Symposium on International Nuclear Safeguards, Vienna, 14–18 March 1994, vol. I, quotation on p. 20.
20. For a detailed overview on tritium uses, production and eventual control see M. Kalinowski and L. Colschen, International Control of Tritium to Prevent its Horizontal Proliferation and to Foster Nuclear Disarmament, *Science and Global Security*, vol. 5, no. 2, 1994/95, p. 130.
21. Arms reductions are releasing large amounts of tritium — decades worth — that the United States and the Russian Federation can stockpile. If comprehensive disarmament were envisaged in a comparable time, they might live with a ban on tritium production. The United Kingdom and France may have a greater problem because their reductions are smaller percentage-wise.
22. S. Thorstensen, note 8, p. 4.
23. In the United States, the isotopic composition is classified as long as the material is in warhead component form. As soon as this form is modified, the masses and isotopic composition can be revealed. See J.T. Markin and W.D. Stanbro, Policy and technical issues for international safeguards in nuclear weapon states, in: *International Nuclear Safeguards 1994*, Proceedings of the Symposium on International Nuclear Safeguards, Vienna, 14–18 March 1994, vol. II, p. 639. In the Russian Federation, the isotopic composition of disarmament materials remains classified.
24. D. Albright, F. Berkhout and W. Walker, ibid.; see Chapter 15, The control and disposition of fissile materials: the new policy agenda.

Reconciling IAEA Safeguards Requirements in a Treaty Banning the Production of Fissile Material for Use in Nuclear Weapons or other Nuclear Explosive Devices

Thomas E. SHEA

IAEA Safeguards Agreements are in force in every state known to have nuclear activities. Three types of Safeguards Agreements have evolved, and they differ in the undertakings accepted by states and in the obligations and scope of IAEA verification activities. To some extent, the verification arrangements adopted in a treaty banning the production of fissile material for use in nuclear weapons or other nuclear explosive devices (the 'Cut-Off Treaty', in this article), will affect — and be affected by — existing control systems that also focus on the production and use of fissile materials, chief among them IAEA safeguards. In particular, differences in the scope of coverage, the verification objectives, the measures and technology applied, and the evaluation methods and reporting may arise. As negotiation of a Cut-Off Treaty proceeds, it is important that efforts to rationalize overlapping requirements and implementation assure that IAEA safeguards and the Cut-Off verification systems are mutually complementary, and that the final outcome assures that the totality of verification undertakings is effective and efficient.

IAEA safeguards are in transition and the changes coming about may complicate that rationalization. The strengthened safeguards system will improve the ability to detect undeclared production of fissile materials on the one hand, but the legal provisions and the methods to be applied will require several years for full implementation.

In May of 1997, the IAEA Board of Governors adopted a model for a protocol to extend the provisions of existing safeguards agreements to strengthen the ability of IAEA safeguards to detect the undeclared production of fissile material. As additional states complete their constitutional ratification requirements for the Additional Protocol, steps are underway to change IAEA safeguards by integrating newly provided rights for increased access to information, increased inspection access and the use of new technologies to improve the effectiveness and efficiency of safeguards, with the verification arrangements embodied in the original safeguards system. The resulting strengthened safeguards system will, in the course of the next few years, be capable of responding effectively to any plausible proliferation threat. The assurances gained concerning the absence of clandestine fissile material production facilities within states may provide a justification for reducing requirements for certain current inspection activities, with resulting cost-savings.

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Fissile Material vs. Nuclear Material

The term "fissile material" is not actually used in implementing IAEA safeguards agreements. Rather, IAEA safeguards are applied to "nuclear material" — any *source* or *special fissionable material*[1] as defined in Article XX of the IAEA Statute. Special fissionable material is defined as: "plutonium-239; uranium-233; uranium enriched in the isotopes 235 or 233; any material containing any of the foregoing; and such other fissionable material as the Board of Governors shall from time to time determine." The term source material is defined in the IAEA Statute as "uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound, or concentrate; any other material containing one or more of the foregoing in such concentration as the Board of Governors shall from time to time determine; and such other material as the Board of Governors shall from time to time determine."

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In IAEA safeguards, "nuclear material" is further categorized into "direct-use nuclear material" that could be used in the manufacture of nuclear weapons or other nuclear explosives without reprocessing or further enrichment, and "indirect-use nuclear material" that would require irradiation or enrichment to make it suitable for use in nuclear weapons. For the purposes of IAEA safeguards, direct-use nuclear materials are: plutonium except that containing 80% or more of the isotope plutonium-238, uranium containing 20% or more of the isotope uranium-235, and uranium-233. "Separated direct-use nuclear materials" are those direct-use nuclear materials that have been separated from fission products and thus the processing that would be required for their use in nuclear weapons is substantially less and the times required substantially shorter than if mixed with highly radioactive fission products. The definition of fissile material to be included in the Cut-Off Treaty may be close to this definition of separated direct-use nuclear material. Differences in these basic definitions could complicate the obligations as well as actions required of states and the implementation of IAEA safeguards and Cut-Off verification.

Different Types of IAEA Safeguards Agreements and Arrangements

IAEA safeguards are applied under different types of agreements and arrangements and the scope, objectives, measures, technology, evaluations and reporting employed may vary.[2]

At present, 183 states have undertaken in treaty commitments not to develop or otherwise acquire nuclear weapons or other nuclear explosives. Such states accept "Comprehensive IAEA Safeguards Agreements" (CSAs) to demonstrate their non-proliferation *bona fides*.

Four of the remaining nine states have or plan nuclear activities. Cuba has two partially completed facilities subject to IAEA safeguards. There are no known nuclear materials in Cuba. In the three remaining states with nuclear activities (India, Israel and Pakistan), IAEA safeguards are applied at specific facilities to the facilities themselves or to certain equipment, nuclear material or other material (such as heavy water).

The five remaining states with nuclear activities are nuclear-weapon states (NWS) parties to the Treaty for the Non-Proliferation of Nuclear Weapons (NPT) and all five have in force Voluntary Offer Safeguards Agreements on certain of their nuclear facilities and materials.

In addition to these different types of safeguards agreements, three additional safeguards arrangements are noteworthy.

Safeguards in CSA States[3]

IAEA safeguards are said to be the cornerstone of the international non-proliferation regime, and CSAs are the cornerstone of IAEA safeguards. CSAs obligate states to submit *all* nuclear material to IAEA safeguards and obligate the IAEA to apply safeguards to *all* nuclear materials submitted by states pursuant to those CSAs. The scope of IAEA safeguards in states pledging not to develop or otherwise acquire nuclear weapons includes what is understood to be "fissile material", together with nuclear materials other than fissile material. Under CSAs, IAEA safeguards focus on the state and proliferation-related activities that the state itself might direct or carry out if that state — with all of its available resources — were to seek to develop or otherwise acquire nuclear materials for use in a nuclear weapons programme. Thus, CSA verification activities address possibilities involving both declared nuclear activities and undeclared activities; they are intended to confirm that all nuclear materials are submitted to safeguards and remain committed to peaceful use.

Two verification objectives guide the implementation of IAEA safeguards under CSAs:

- to *detect the diversion of significant quantities of nuclear material* declared by the state from peaceful use to the manufacture of nuclear weapons or other nuclear explosives, or for any other purpose; and
- to verify the correctness and completeness of the declarations made by states, including the objective to *detect undeclared production* of fissile materials anywhere on the territory of the state or under its control.

In that CSAs are intended to provide assurance of non-proliferation, the safeguards system for CSAs is designed to alert the international community before a state could acquire its first nuclear weapon. This non-proliferation focus has led to requirements that include not only fissile materials, but the materials from which fissile materials are produced: the safeguards applied to low enriched uranium (LEU), natural and depleted uranium and thorium in CSAs provide additional opportunities for detecting actions that might be taken by a state intent on acquiring nuclear weapons or other nuclear explosives. (The only nuclear materials that are not subject to inspection in CSA states are the small amounts that are permitted to be exempted from safeguards, practicably irrecoverable nuclear materials on which safeguards have been terminated, and nuclear materials designated for non-proscribed military applications on which safeguards are not required.)[4]

Measures Related to Verification at Declared Facilities in CSAs

Over the years, the standard criteria have been adopted to guide the implementation of safeguards at declared facilities, affecting the extent and quality of information to be provided by states, design information verification activities, the safeguards approach to be applied at the facility to satisfy safeguards goals, and specific requirements related to inspection frequencies, inspection activities and the outcome of those activities. For plutonium and for uranium-233, an amount of 8kg is considered adequate for a state to produce its first nuclear weapon, taking into account process losses and the need to be conservative in the design, absent the benefit of nuclear tests. For high enriched uranium (HEU), an amount of 25kg of the isotope uranium-235 is similarly considered adequate. Depending on the form and purity of the materials, the times estimated as necessary for a state to complete the fabrication of its first nuclear weapon once these materials are available ranges from as low as seven to ten days for pure metal, to as long as three months when reprocessing is required, or one month if enrichment is required. For these materials, for LEU, natural and depleted uranium, and for thorium, the minimum time required for irradiation and reprocessing is estimated to be one year. These criteria reflect the non-proliferation objective for CSAs, establishing fixed quantity definitions to verification parameters that serve as the basis for planning and evaluating IAEA safeguards.

The structure and content of CSAs and the infrastructure for implementing safeguards may affect Cut-Off Treaty verification not only in CSAs, but may also be of interest in other states as well. Below the level of the Agreements, subsidiary arrangements are concluded as part of the legal framework under which the safeguards are implemented. Subsidiary arrangements include a General Part and a Facility Attachment for each facility identified. The General Parts of the Subsidiary Arrangements are standardized to the extent possible, and while the Facility Attachments for different types of facilities begin with "models", substantial adaptations are often required to accommodate the specific characteristics of individual facilities. Facility Attachments relate specific obligations and inspection rights applicable at individual facilities to specific paragraphs in the Safeguards Agreement with a state.

Under CSAs, a "State system of accounting for and control of its nuclear material" (referred to as a SSAC) must be created to be responsible for implementing effective accountancy arrangements and to control imports and exports. States must make extensive declarations regarding their past, present and future nuclear activities at safeguarded facilities and report at specified periods on their nuclear material inventories and flows. When a CSA first enters into force, the initial inventory declaration is investigated closely to assure that it is complete and accurate. Subsequently, in relation to each facility a state declares, the state is required to carry out material balances annually and to report material unaccounted for on the basis of a measured physical inventory and measured inventory changes. Those state declarations are verified by the IAEA to assure that they are complete and accurate, and that declared nuclear materials are not diverted to the manufacture of nuclear weapons or other nuclear explosive devices.

Measures Related to Clandestine Fissile Material Production Under CSAs

The discovery of an extensive clandestine nuclear weapons programme in Iraq, an NPT state subject to a CSA, gave evidence to the fact that a safeguards system that concentrated on verifying declared activities was inadequate. In strengthening the safeguards system, the IAEA Board of Governors recognized that to address the possibility of clandestine operations, some provision for access had to be provided to locations anywhere within the territory of a CSA state or under its control. Similar needs were included in the verification provisions of the Chemical Weapons Convention and the Comprehensive Nuclear-Test-Ban Treaty (CTBT). While the principal focus of INFCIRC/153 is on declared facilities and nuclear materials, INFCIRC/153 includes provisions for special inspections that could be requested by the IAEA anywhere on the territory of the state. However, as became evident in the case of the Democratic People's Republic of Korea (DPRK), the request for a special inspection has not been accepted. The Additional Protocol to the CSA, based on INFCIRC/540,[5] was created to extend the reach of INFCIRC/153 Agreements, providing the additional information, access and technology required for IAEA

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Safeguards to address all plausible means through which a state party to a CSA might proceed if it were to decide to violate its undertakings and attempt to acquire nuclear weapons.

The provisions of INFCIRC/540 allow the IAEA to require information on states' nuclear programmes including research and development, facilities that never operated or were decommissioned, and activities relating to the manufacture or import of equipment that could be used to produce or purify fissile materials. It allows for complementary access to resolve questions pertaining to activities or materials, including managed access to sensitive locations. Integrating the assurances regarding possible clandestine facilities or undeclared operations in declared facilities provided through the Additional Protocol will allow the IAEA to adapt the verification requirements at declared installations. Integrated safeguards under CSAs together with Additional Protocols are intended to use country profiles as a means to differentiate between the verification activities needed without discriminating among states.

The strengthened safeguards system will include verification activities from the basic CSA together with new verification possibilities provided by the Additional Protocol. The mechanisms for accomplishing that integration are being developed, and implementation will likely proceed in stages, addressing states with limited nuclear operations and building on experience before advancing to increasingly complex situations.

The goal is to conclude Additional Protocols in all states having made non-proliferation commitments by 2000, i.e. all CSA states. At each of the four annual meetings of the IAEA Board of Governors, a number of Additional Protocols are put forward for authorization for signing, and the total number of states is changing too rapidly to make including a table meaningful. In considering the relevance of IAEA Safeguards to Cut-Off Treaty verification in states pledging in one or more treaties not to acquire nuclear weapons, whether or not an Additional Protocol is in force should be an important consideration.

IAEA Safeguards in Other States With or Planning Nuclear Activities

IAEA safeguards implementation in Cuba, India, Israel and Pakistan are applied under Safeguards Agreements that were established as conditions for exports to those states of research or power reactors, or components thereof, or nuclear fuel or heavy water. These agreements stipulate that any fissile material created through irradiation in those reactors is also subject to safeguards, and any plant processing or using that fissile material will be subject to safeguards as long as that safeguarded fissile material is in the facility. Note that while the safeguards verification requirements at a given type of facility generally follow the requirements established in CSAs, specific differences may arise from the fact that the facility itself or equipment or material may be subject to safeguards, and the safeguards agreement may include provisions that reflect the selective nature of such safeguards agreements — especially provisions for substitution.

Of the safeguards applications in this category, the most germane to a Cut-Off Treaty might be the PREFRE Reprocessing Plant in India which is subject to IAEA safeguards when it reprocesses spent fuel that is under safeguards; plutonium recovered at PREFRE has been subject to safeguards through MOX manufacturing; and the fuel assemblies remain subject to safeguards through and following irradiation at the Tarapur Atomic Power Station boiling water reactors. The provisions of the applicable safeguards agreements allow for substitution, and in this case, plutonium not subject to safeguards was substituted for the safeguarded plutonium during MOX fuel manufacturing. When the assemblies were completed, the plutonium content was measured and the amounts contained were returned to safeguards.

Note that the Additional Protocol is applicable to all states, including states subject to safeguards agreements based upon INFCIRC/66.[6]

Safeguards Implementation in NWS Parties to the NPT

As NWS of the NPT, France, the People's Republic of China, the Russian Federation, the United Kingdom and the United States have entered into limited scope voluntary offer safeguards agreements (VOAs) modelled on CSAs. These VOA agreements place no obligation on the state in relation to the nuclear materials to be subject to safeguards and they permit the state to withdraw nuclear materials and to remove facilities from the list designated by the state which the Agency can select for the purposes of safeguards implementation. Moreover, there is no obligation on the Agency to carry out safeguards at facilities designated by the state.

The provisions of the VOAs allow many more opportunities for verification than can be implemented under the funding provided. The IAEA budget has remained at zero-growth for more than ten years now, even as additional mandatory verification activities arose in South Africa, Argentina and Brazil, and in the newly independent states of the former Soviet Union. As budget restrictions limit the activities that the Agency can carry out, safeguards implementation in these states is an early casualty. Note that when safeguards are applied at a facility in one NWS party to the NPT under a VOA, the same requirements apply as if the facility were in a CSA state.

The IAEA budget has remained at zero-growth for more than ten years now, even as additional mandatory verification activities arose in South Africa, Argentina and Brazil, and in the newly independent states of the former Soviet Union. As budget restrictions limit the activities that the Agency can carry out, safeguards implementation in these states is an early casualty.

At present, the most germane application of IAEA safeguards to a Cut-Off Treaty is at enrichment plants in China and the United Kingdom.

All nuclear facilities in France and the United Kingdom, except those dedicated to nuclear weapon programmes and naval reactor programmes are subject to Euratom safeguards under the provisions of the Treaty of Rome. Euratom is seen as a regional control authority and a partnership arrangement has evolved where both the IAEA and Euratom apply safeguards, primarily in non-nuclear-weapon states (NNWS) of the European Union. The partnership arrangement was established to eliminate unnecessary duplication of work, thereby reducing intrusion into normal plant operations and reducing the costs to the IAEA and Euratom. The arrangements are implemented in such a manner that the IAEA and Euratom are each able to derive independent conclusions, according to their respective requirements. In France and the United Kingdom, the funding provided has not been adequate to allow for the IAEA to apply safeguards except in limited situations. Euratom has gained extensive experience in applying its verification measures in both states, and Euratom's experience and existing capabilities at reprocessing plants and at enrichment plants in France may affect and be affected by verification under a Cut-Off Treaty.

Note that the Additional Protocol is applicable to all states, including NWS parties to the NPT. All five NWS of the NPT have, or will soon have, signed Additional Protocols based on INFCIRC/540; however, for the most part, the Protocols adopted by these states are intended to provide the IAEA with additional information to assist the IAEA in detecting suspicious activities in other states. These states have not adopted any obligation to cease production of fissile material and the VOAs including the Additional Protocols may not be useful to meeting obligations under the Cut-Off Treaty in relation to fissile material production in those states. However, the Protocols in NWS parties to the NPT may affect or be affected by considerations that might be included in the Cut-Off Treaty relating to exports of equipment or materials that could assist other states in efforts to acquire the capability to produce fissile material — including material or equipment specifically designed for that purpose, or dual-use equipment or material.

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Other Relevant IAEA Verification Activities

In addition to the normal range of safeguards implementation, three additional areas of verification may be relevant to the Cut-Off Treaty:

- The IAEA is carrying out extended verification measures in Iraq under the provisions of United Nations Security Council resolution 687, including unrestricted access to locations of interest and wide area environmental monitoring to detect clandestine production of fissile material. The experience gained in this extreme situation may be of benefit in considering the access provisions to be established under the Cut-Off Treaty — the rights granted and the difficulties encountered;
- The IAEA is monitoring a freeze on operations in facilities in the DPRK in relation to an Agreed Framework concluded between the United States and the DPRK, including monitoring a freeze on operations at the reprocessing plant at Nyongbyon, which is being maintained at operational stand-by. Again, the experience gained in relation to attempts to implement special inspections may be of benefit in considering provisions for extraordinary inspections under a Cut-Off Treaty; and
- The IAEA is participating with the Russian Federation and the United States in a Trilateral Initiative to develop a verification system for excess defence fissile materials in those states, including provisions for terminating verification of weapon-origin plutonium following irradiation in nuclear power reactors to specified levels. Such provisions may also be relevant if termination conditions are addressed for fissile materials subject to verification under a Cut-Off Treaty.

Safeguards Measures and Technology Related to Reprocessing and Enrichment

As the scope and verification requirements for the Cut-Off Treaty are established, the relevance of IAEA experience and existing requirements in states will enable detailed investigations to proceed for specified types of facilities and for specific facilities as appropriate. Given the negotiation mandate, it would appear that verification of reprocessing and enrichment operations will logically be required, and thus a preliminary review of IAEA experience in applying safeguards at enrichment and reprocessing plants may be useful.

Declared Reprocessing Plants

The plutonium produced in nuclear reactors is separated from the uranium, fission products and other actinides in reprocessing plants. With very few exceptions, all plutonium reprocessing plants employ the same process technology, the Purex process. (Uranium-233 is produced in a similar manner by irradiating thorium, and separated through a similar process; however, no uranium-233 reprocessing plants are subject to IAEA safeguards.) Reprocessing plants require processing of intensely radioactive materials and hence require remote processing within very substantial structures to contain the radioactivity. These characteristics, together with difficulties inherent in measuring accurately the amounts of plutonium (or uranium-233) at the starting point of the processing, make the application of safeguards complex and more expensive than any other safeguards application.

Safeguards at reprocessing plants are designed to detect misuse of the facility (undeclared reprocessing) and diversion from declared flows and inventories of plutonium and uranium. Meeting safeguards verification requirements is most difficult in large operating plants, as the IAEA safeguards goals are fixed in terms of amounts necessary for manufacturing one nuclear weapon, and as those amounts become small in relation to the total amounts of nuclear material processed, the safeguards approach must be expanded in scope and made increasingly intrusive in order to provide the required assurances that the plants are not misused and that the nuclear materials are accurately measured, declared and are not diverted. The technical problems are further complicated if the plants operated before safeguards were applied, and if the plant instrumentation is incomplete or unreliable. The safeguards literature is rich with information describing the technical means that have been developed for reprocessing plants.

The safeguards approach for a reprocessing plant will depend on a range of considerations, chief among which is its operational status. The following conditions may apply:

- continued reprocessing operation;
- operation for non-reprocessing purposes (e.g., removal of americium-241 from plutonium, waste fractionation, etc.);
- stand-by (here the verification requirements depend very much on the length of time between a notice of intent to resume operations and the actual resumption);
- decommissioning (here the safeguards approach is progressively simplified as the time and effort required to resume operations increases with the destruction, entombment or removal of key components); and
- decommissioned or abandoned. (The frequency with which periodic checks are required depends on whether the buildings remain and, if so, if they remain in use; the methods may entail periodic visits or satellite imagery analysis, depending on cost considerations.)

The cost and effort required can vary from almost no cost for decommissioned or abandoned facilities up to continuous inspection with tens of millions of dollars of verification equipment.

IAEA safeguards at reprocessing plants begin with the examination of information required of the state on relevant aspects of the design and construction of the facility, on its operation and on the nuclear material accountancy system employed. Design information reviews are made early in the consideration of the safeguards approach for a facility to determine whether the information is sufficient and self-consistent. During construction, commissioning and thereafter during normal operations, maintenance and modifications, and into decommissioning, the design information is verified through inspector observation and appropriate measurements and tests to confirm that the design and operation of the facility conforms to the information provided. In addition to these methods, environmental sampling may be applicable depending on the circumstances, as a means to detect reprocessing of plutonium with different characteristics. This safeguards measure provides the basis for determining the other elements of the safeguards approach for a given facility and the basis for applying all other safeguards measures.

For each reprocessing facility, depending on its operational status, whether it is a small, medium or large-scale plant, and facility-specific features, appropriate combinations of the following measures are combined with design information verification activities in the safeguards approach for the facility:

- application of containment and surveillance at key parts of the plant, to maintain continuity of knowledge of verified information and to track operations to determine whether or not observed operations conform to operator declarations;
- application of measurements, including measurements made by the operator for accountancy, criticality safety or process control and measurements made by the IAEA using IAEA equipment or, under suitable arrangements, using operator equipment;
- solution measurement and monitoring systems, to track the movement of solutions containing nuclear materials within the process area and to provide authenticated volume measurements of nuclear materials in solutions;
- near real-time accountancy, to detect plutonium losses within the specified monthly timeliness intervals;
- nuclear materials accountancy, involving annual material balances based upon verified physical inventories and physical inventory changes (this includes the analysis of shipper-receiver differences and material unaccounted for over successive material balance periods); and
- cumulative nuclear materials accountancy, involving total and trend analysis over the full period during which IAEA safeguards are applied at the facility.

Safeguards at reprocessing plants include the taking of samples for analysis at the IAEA Safeguards Analytical Laboratory, located in Seibersdorf, Austria. Sample preparation at the facilities includes spiking with reference materials and dilution to reduce the radioactivity of the samples to facilitate shipment and handling. Shipping such samples is expensive and requires appropriate radiation protection measures.

The verification equipment used at reprocessing plants includes standard seals and surveillance equipment, plus specialized systems:

- pneumatic measurement systems for determining the volume and density of solutions in instrumented vessels;
- secure sample containers to protect samples from tampering;
- densitometry equipment to permit IAEA verification of the concentration of plutonium in solutions before, during and following its separation and purification (K-edge densitometry for purified solutions and hybrid K-edge densitometry for solutions containing fission products and uranium); and
- in large-scale plants, on-site analytical laboratories are necessitated in view of the number of samples required and the timing for analysis.

Clandestine Reprocessing Plants

In a CSA state, any undeclared reprocessing would constitute a clear violation of the provisions of the Agreement and the Additional Protocol. Reprocessing operations normally involve the release of gaseous fission products into the atmosphere and the release of particulates, some of which are deposited at significant distances from the facility. The detection measures for detecting clandestine plants are as follows.

Enhanced Information Analysis: Under the provisions of the Additional Protocols, CSA states are required to be thorough in providing information relating to research and development concerned with reprocessing, manufacturing and importing specialized vessels for reprocessing and the construction, operation and decommissioning of any reprocessing plants, past, present and future. The IAEA analyzes the information provided and compares that information with information obtained from a range of sources, including:

- information obtained through the implementation of safeguards within the states;
- information reported to the IAEA involving transfers of nuclear materials and specified items of equipment;
- information obtained through other IAEA activities, including technical cooperation projects;
- open-source information from scientific journals and the media; and
- other information as states may provide.

Complementary Access: Under the provisions of the Additional Protocol, the IAEA has the right to request access to locations to resolve inconsistencies in information provided. The specific provisions for such access are complex and a careful analysis will be required to determine their relationship to Cut-Off Treaty requirements as negotiations proceed.

Environmental Sampling: Environmental samples may be taken under existing provisions of the Additional Protocol at locations where complementary access is provided. Additional provisions for wide-area environmental sampling are under consideration and approval by the Board of Governors is required before this feature of the Additional Protocol can be implemented.

Declared Enrichment Plants

IAEA safeguards at a uranium enrichment plant are intended to meet three objectives:

- to detect the production of HEU or excess high enrichment production if high enrichment production is declared;
- to detect excess LEU production (that might subsequently be further enriched at a clandestine plant or within a plant under safeguards, with a higher risk of detection);[7] and
- to detect diversion from the declared uranium product, feed or tails streams.

The nuclear materials accountancy measures applied to detect diversion from the declared feed, product and tails streams in an enrichment plant provide a means to assure that a plant is not being used to produce HEU, and in those cases where a low enrichment plant has been used earlier to produce HEU, this method assumes increased importance.

While essentially all reprocessing plants use a single process, nine uranium enrichment technologies have been advanced. Some of these technologies are unlikely to be exploited and some would no longer be selected because of very high electrical power requirements. While the safeguards approach for any enrichment plant will include common elements, the differences in the various process characteristics and the plants requires different safeguards methods.[8] While IAEA safeguards have been applied primarily to gaseous centrifuge plants, the IAEA has carried out investigations in relation to aerodynamic nozzle enrichment plants, gaseous diffusion plants, molecular laser enrichment (MLIS) and electromagnetic (calutron) enrichment systems. Limited studies have been carried out to consider safeguards at atomic vapour laser enrichment (AVLIS) plants, but little if any work has proceeded in relation to the remaining technologies that have yet to advance to the point of being incorporated in industrial scale plants: chemical exchange enrichment, ion exchange enrichment and plasma separation enrichment.

As in the case of reprocessing plants, design information examination and design information verification are central to the implementation of IAEA safeguards at enrichment plants. Enrichment technology is considered to be proliferation-sensitive and thus IAEA inspector access to the areas where enrichment equipment is installed is restricted by the technology holders, and inspector observation of the inside details of enrichment equipment is forbidden, as is access to critical plant operating parameters. Verification arrangements have been established within these restrictions that allow the IAEA to meet the objectives indicated.

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Design information examination and verification provides a reference for understanding the normal steps for introducing feed and removing product and tails, and for assuring thereafter that no temporary or permanent modifications are made that would allow the plant — or any part thereof — to be used for the production of undeclared HEU. During construction, commissioning, during normal operations, maintenance and modifications, and into decommissioning, the design information is verified through inspector observation and appropriate measurements and tests to confirm that the design and operation of the facility conforms to the information provided.

Environmental sampling has proven to be an extremely potent method for determining whether or not an enrichment plant produces HEU. Clearly, if the plant is producing HEU for a non-proscribed purpose, or if a low enrichment plant was formerly used for HEU production or is near a high enrichment plant, environmental sampling may be less useful. The safeguards approach in such facilities would require greater emphasis on other aspects of the safeguards, but even in such circumstances, cluster analyses of particulates over time may provide a basis for detecting new production, as may differences in minor isotope ratios.

For a given enrichment technology, in a manner similar to that for declared reprocessing plants, the safeguards approach for an enrichment plant will depend to a great extent on the operational status of the facility. In particular, the following conditions are fundamental to establishing effective and efficient safeguards:

- operating enrichment plants:
  - — producing HEU for non-proscribed purposes (here the verification must assure that only the declared amounts of HEU are produced, and environmental sampling may be of little if any relevance);
  - — producing LEU in a plant reconfigured from earlier high enrichment production or in a

plant nearby another plant used for HEU production (here the verification activities intended to detect undeclared HEU production will be more complicated due to remaining traces of HEU, so, for example, environmental sampling may be of little relevance);

— producing LEU and never having produced HEU;

- operational standby (again, as for reprocessing plants, the verification requirements will differ depending on the advance notification interval required);
- decommissioning (the safeguards activities will be progressively simplified and the plant is dismantled; the destruction or disposition of the enrichment equipment removed should be monitored); and
- decommissioned or abandoned (here again, as for reprocessing plants, the inspection methods and frequency will depend upon the final state of the structures and periodic assurance that steps are not being taken to return a decommissioned or abandoned plant to operation will differ accordingly).

For each enrichment plant, depending on its technology, operational status, capacity and layout, the following measures are incorporated in the safeguards approach:

- measurements of the amounts of uranium and the enrichments of uranium in feed, product and tails cylinders, by means of weighing the cylinders and the use of non-destructive assay systems to measure the uranium enrichment, and sampling for analysis at the IAEA Safeguards Analytical Laboratory;
- applications of containment and surveillance on feed, product and tails cylinders, and at key parts of the plant, in particular at the uranium feed point and the product and tails removal points (integrated sealing-surveillance systems are being used at some plants that allow the facility operator to attach and remove seals as an efficient means to obtain assurance that all cylinders attached or detached from the declared feed and take-off points are verified), and at locations where instruments are installed to maintain continuity of knowledge of verified information and to track operations to determine whether or not observed operations conform to operator declarations;
- determinations that uranium in the process piping contains less than 20% of the isotope uranium-235, through continuous enrichment monitors or specialized measurement systems used in conjunction with limited-frequency unannounced inspections inside the cascade areas of some centrifuge plants;
- in other centrifuge plants, in-line instruments will be introduced for measuring the actual enrichment of the uranium in uranium hexafluoride gas in the feed, product and tails lines, and mass flow meters on the product flow line;
- in some facilities, use of limited frequency unannounced access inspections into the cascade hall to detect plant modifications that might signal high enrichment operations;
- in some facilities, monitoring of the separative work produced between successive inspections and comparison of those amounts with operator declarations and supportive inspection data;
- nuclear materials accountancy, involving annual material balances based upon verified physical inventories and physical inventory changes (this includes the analysis of shipper-receiver differences and material unaccounted for over successive material balance periods); and

- cumulative nuclear materials accountancy, involving total and trend analysis over the full period during which IAEA safeguards are applied at the facility.

Clandestine Enrichment Plants

The methods used to detect undeclared enrichment plants are essentially as for undeclared reprocessing. Enrichment operations normally result in the release of aerosols — especially at locations where connections to the process piping are made, but also through the plant ventilation system. These aerosols may not travel very far, and thus environmental sampling is likely to be effective close by such facilities.

The difficulty in finding emissions from clandestine enrichment plants is further compounded by advances in enrichment technology that greatly reduce the size of plants and reduce the electrical power requirements.

Enhanced Information Analysis: States are required to be thorough in providing information relating to research and development linked to enrichment, manufacturing and importing enrichment equipment and specialized materials (carbon fibre vessels and maraging steel, for example) and the construction, operation and decommissioning of any enrichment plants, past, present and future. As for reprocessing, the IAEA analyzes the information provided and compares that information with information obtained from the sources identified above in relation to reprocessing.

Complementary Access: As above, for reprocessing.

Environmental Sampling: As for reprocessing, environmental samples may be taken under the provisions of the Additional Protocol at locations where complementary access is provided. Additional provisions for wide-area environmental sampling are under consideration, and approval by the Board of Governors is required before this feature of the Additional Protocol can be implemented, but the detection of enrichment at points distant from plants is less likely.

Evaluations and Reporting of IAEA Safeguards Findings

Many other fundamental features of IAEA safeguards may be relevant to verification of a Cut-Off Treaty, including the following.

Autonomy of Agency

The Director General of the IAEA is empowered to bring to the Board of Governors suspicions of violations of the provisions of safeguards agreements, and the IAEA is empowered to bring to the United Nations Security Council situations which suggest that safeguards agreements may have been violated. The Director General is authorized to receive any information that may bear on a given situation, but the Director General is responsible for determining whether, how and when to act on such information.

Confidentiality

IAEA safeguards are carried out under conditions that require the Agency to protect the confidentiality of information relating to facility design and operation, inspection findings and evaluations, especially those at the level of the state.

Statements

Statements summarizing the activities carried out during each inspection are provided to the state shortly after each inspection, and a summary statement with conclusions regarding the outcome of inspections is provided annually. These statements are also "safeguards confidential".

Consultations

In determining the most efficient means to meet safeguards objectives, consultations are held in a cooperative framework. When anomalies and discrepancies are detected in the course of inspections or subsequent evaluations, consultations are held to find prompt and effective means for their resolution.

Special Inspections

The Director General is empowered to request a Special Inspection in a CSA state, based upon unresolved questions that suggest that a state may be in violation of its CSA provisions. The provisions of the Additional Protocols for complementary access are intended to improve the ability to resolve significant questions in the light of experience.

Safeguards Implementation Report

Each April, the IAEA Secretariat prepares a report to the Board of Governors summarizing all verification activities carried out and the conclusions derived therefrom. (Problem matters are brought to the attention of the Board as they arise.)

Concluding Remarks

IAEA safeguards began in the 1960s and have continued to evolve, without pause, as new verification responsibilities were assigned, as peaceful nuclear operations increased in size and complexity and as international relations posed new challenges. At present, 220 IAEA inspectors carry out approximately 11,000 days of inspection work each year, using 110 different verification systems that have been developed under sixteen ongoing IAEA Member State Support Programmes. The legal, technical and administrative arrangements adopted in different states and in different facilities respond to obligations mandated through Safeguards Agreements. In a wide range of areas, consideration of the existing safeguards arrangements will ensure that Cut-Off Treaty verification and IAEA safeguards are implemented in ways that provide the maximum value at the minimum cost.

Notes

1. "Fissionable" nuclei will fission when struck by fast neutrons having appreciable kinetic energy, while "fissile" nuclei will fission when struck by fast or slow neutrons with any amount of kinetic energy, including neutrons with essentially no kinetic energy. "Fissile" nuclei are therefore "fissionable", but only some "fissionable" nuclei are "fissile". Uranium-233, uranium-235, plutonium-239 and plutonium-241 are "fissile" nuclei; uranium-238, plutonium-238, 240 and 242, neptunium-237, americium-241 and 242(m) are examples of "fissionable" nuclei that are not "fissile".
2. Details on the status of Safeguards Agreements are published in IAEA Annual Reports and are available on the IAEA web site: http://www.iaea.org/worldatom/.
3. All CSAs are based upon INFCIRC/153, "The Structure and Content of Agreements between the Agency and States in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons." INFCIRC/153 is available at the web site noted above.
4. Note that no state has ever exercised the provision allowed in CSAs to designate nuclear materials for non-proscribed military applications that employ the fission characteristics of nuclear materials. States have exempted safeguards on depleted and natural uranium for use in ceramics, for example, and as a catalyst in petrochemical processes, and on depleted uranium metal for use as ballast material in aircraft and boats and in military applications involving armor-piercing projectiles. The provisions for excluding nuclear material from safeguards for non-proscribed military activities are set forth in paragraph 14 of INFCIRC/153.
5. INFCIRC/540, Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards. INFCIRC/540 is available at the web site given in note 2.
6. INFCIRC/66/Rev.2: The Agency's Safeguards System (1965) as provisionally extended in 1966 and 1968. INFCIRC/66 is available at the web site identified in note 2.
7. Note that more than 80% of the separative work required to produce uranium containing concentrations of uranium-235 of 90% or more is spent in raising the enrichment from natural levels (0.71% uranium-235) to approximately 4% enriched. A much smaller top-end facility would be needed to increase the enrichment from 4% to high enrichment levels than if the facility were to start with natural uranium.
8. The IAEA has no experience in relation to plutonium enrichment processes, only one of which has been suggested (AVLIS).

Transparency and Fissile Materials

Frans Berkhout & William Walker

Opacity was one of the founding principles of the nuclear age. Secrecy about scientific principles, nuclear technologies, and the scale of capabilities and policies was pervasive. For states reliant on nuclear deterrence, keeping nuclear activities opaque to the outside world (and to all but a few within government systems) has been justified mainly on the grounds that knowledge about nuclear arsenals and weapon designs should be limited. Opacity, and the uncertainty it created for the other side, was viewed as a cornerstone of security, on the ground that knowledge about weapon deployments and designs enables adversaries to improve their strategic responses.

For materials bound up in military nuclear programmes (weapons and submarines), the situation has not fundamentally changed in the 1990s. While there is greater transparency about warhead numbers — due to nuclear arms control agreements negotiated by the United States and the former Soviet Union/Russian Federation, and voluntary disarmament by France and the United Kingdom — the size, form and location of inventories of nuclear weapon materials has remained predominantly classified.

Opacity has also played an important role in civil nuclear programmes, for commercial and physical security reasons. However, a much higher degree of transparency has existed about civil fissile material inventories, especially those in non-nuclear-weapon states (NNWS) parties to the Nuclear Non-Proliferation Treaty (NPT). Transparency is achieved in many ways, but its central component is the international safeguards system that operates through the International Atomic Energy Agency (IAEA). In contrast to military programmes, transparency is seen as a condition of international confidence in the peaceful use of nuclear energy.

Today there is a demand for greater transparency about many aspects of nuclear activities, both civil and military. On the civil side, perennial concerns about economic, safety and environmental performance are forcing the nuclear industry to be more open in its relationships with regulators, financiers and other stakeholders. In the last few years there have also been important developments in the international safeguards regime, as well as a number of voluntary transparency initiatives, such as the international plutonium management guidelines agreed in 1997. On the military side, there has also been a recognition in some of the nuclear-weapon states (NWS) of the need to reverse the Cold War attachment to opacity and introduce progressively more transparency. This process has been for the most part *ad hoc*. Only slowly and unevenly are the veils of secrecy being lifted.

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This paper aims to describe why the demand for transparency has arisen, defines the main forms and modes of nuclear transparency, and sketches out transparency measures that have been implemented in different contexts.

The Demand for Transparency

The demand for greater transparency about nuclear activities arises for a number of reasons. The first is the desire of states to understand the nuclear capabilities and policies of other states. Although opacity is the usual practice for weapon states, total opacity can be counterproductive. Indeed, arms control has always entailed the managed reduction of opacity. Trust in the intentions of others depends on the ability to be assured that these activities do not pose an unreasonable security or environmental risk. As the norm of transparency is embedded, so transparency itself becomes a control mechanism. Activities come to be designed which anticipate the need for openness, encouraging reciprocity and building confidence. The logic that transparency brings gains in security has become more compelling for both military and civil nuclear programmes.

On the military side, arms reduction and disarmament processes have required greater transparency as a way out of the ‘security dilemma’ that propels arms races. On the civil side, new demands for transparency have been driven by the need to strengthen and broaden the scope of nuclear safeguards, and by the continuing need to gain consent for civil programmes, in particular those entailing the separation and use of plutonium. Transparency is therefore a rational strategy in cases where the formation of trust and consent between states is an objective. Where relationships are characterized by confrontation (as in South Asia today), opacity and uncertainty remains the order of the day.

Second, the demand for transparency arises when states must demonstrate that unilateral and multilateral commitments are being honoured. The more binding the commitments, especially if they are expressed in treaties, the more stringent the transparency measures imposed. With the accretion of nuclear arms control, disarmament and non-proliferation agreements, nuclear transparency has been progressively extended over the past three decades. During the 1990s, this process has accelerated. In particular, the objective of making disarmament measures between the Russian Federation and the United States *irreversible* has led to important new efforts to make formerly opaque military nuclear programmes more transparent to other states. Greater transparency in NNWS has been sought to avoid a recurrence of clandestine acquisition programmes of the type conducted by Iraq.

The objective of making disarmament measures between the Russian Federation and the United States irreversible has led to important new efforts to make formerly opaque military nuclear programmes more transparent to other states. Greater transparency in NNWS has been sought to avoid a recurrence of clandestine acquisition programmes of the type conducted by Iraq.

Third, nuclear transparency has increasingly been needed for reasons of internal security and confidence. In the post-Cold War period, physical security in military nuclear programmes has depended less on the control of people and more on the control of nuclear materials and technologies. This has entailed far greater internal transparency about fissile materials (primarily most forms of plutonium and uranium-235)[1] through the implementation of more effective materials protection, control and accounting (MPC&A) measures in nuclear weapon production systems. More is known to NWS themselves about the management and control of fissile material inventories. Similarly, the beginning of active nuclear disarmament has forced a full and accurate accounting to be made of fissile material production histories. The process of irreversibly removing weapons and materials from military use can only be placed into proper perspective when there is confidence about the initial military inventory. In the longer run, complete disarmament will require a comprehensive and verifiable initial inventory of past production prior to these materials being placed under international safeguards.

Fourth, non-state parties increasingly demand transparency about nuclear activities. Non-governmental organizations (NGOs), neighbours of nuclear facilities, the general public nationally and internationally all have a growing stake in nuclear policy-making. In democracies, nuclear weapons and civil nuclear programmes need to be legitimated in the face of persistent public fear and criticism. Transparency towards these groups helps maintain political acceptance for nuclear activities. Many of the more recent transparency measures therefore have a strong public component. Nuclear transparency is no longer entirely conducted in the form of confidential transfers of information between the bureaucracies of states and international organizations alone.

Finally, technological innovations are making opacity more difficult to sustain, just as they are facilitating transparency measures in which states can place greater confidence. Satellite imaging, environmental monitoring, global communications and various other techniques are forcing states to accept that less and less can be hidden from other states or from the public eye. This is not to discount the continuing innovative efforts made by states to conceal what is most vital to their interests.

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In sum, there exist today many pressures encouraging greater transparency about both military and civil nuclear activities. These pressures have led states to become more transparent to other states (and their proxies in the form of the IAEA), and to themselves. There has also been an increasing tendency for this transparency to become more public, although there is still a long way to go.

Forms and Modes of Transparency

At its simplest, transparency is about the flow of information and knowledge between parties. Someone is allowed to see something they could not see before. This flow may be voluntary, mandatory or involuntary. It may be offered unilaterally, stipulated in an agreement between parties, or gained by other means, such as espionage (national technical means, NTM). Different forms of transparency have different aims. Voluntary transparency aims at demonstrating goodwill or encouraging reciprocity from another party. These voluntary actions are taken in situations where the information being given up is no longer viewed as representing a vital interest, but nevertheless has a value in a general process of confidence-building. It is also a less costly way of gaining trust and agreement, and tends to encourage greater flexibility on both sides. For instance, a voluntary approach (rather than a time-bound reciprocal approach) to the declaration of excess stocks of fissile materials in military inventories allows NWS to phase the movement of stocks from military and civil domains in line with their own budgets and capabilities. In the face of residual uncertainties about the intentions of other states, it also allows them to keep their options open.

Mandatory transparency aims to provide a minimum level of assurance that obligations entered into under bilateral or multilateral agreements are being met by the parties. Typical elements of this form of transparency are: routine declarations of activities and materials stocks; routine inspections of facilities and inventories; and challenge inspections to verify against clandestine activities. The precise modality used will vary between contexts, but the international benchmark for transparency about fissile material stocks is the IAEA safeguards system.

Involuntary transparency is a more difficult and contentious category. The aim here is to gain access to information and knowledge that is being hidden. In other words, it is the active process of overcoming opacity by another party through intelligence gathering. States may use this intelligence as a competitive measure in order to gain a direct advantage over each other. But there is also an important role for intelligence in allowing opponents to understand each other better (including understanding how best to negotiate). In this sense, involuntary transparency can be seen as a confidence-building measure for either side. This process is a basic element of military and diplomatic strategy, especially in relation to nuclear weapons — huge resources being devoted to gathering intelligence about nuclear capabilities. But during the 1990s, involuntary transparency has also played an increasing role in nuclear non-proliferation policy directed at 'cheats' like Iraq and the Democratic People's Republic of Korea (DPRK). Intelligence gathering has played an important, but background, role in the support for UNSCOM inspections, which have sought since 1991 to inventory and disable weapon programmes in Iraq. Another form of involuntary transparency is through the work of researchers, whether academic or working for NGOs.

There are two further aspects of voluntary and mandatory transparency. The first is: *who sees*? Nuclear transparency has many potential audiences . As we have argued, states may be becoming more transparent to themselves, they may be revealing things to other states bilaterally, they may be accepting transparency measures implemented as part of treaty regimes by an international organization, or they may be providing information to non-state parties. Sometimes information is passed directly between states; more often information is passed to a third party — an international organization that acts as an arbiter over the credibility of the information. Much nuclear transparency is therefore indirect.

Hence, transparency faces in many directions and often overlaps. Some forms of transparency are channelled to specific recipients in other states or international organizations (for example, routine reports of fissile material inventory changes by states to safeguards agencies), other forms provide public information to a much less well-defined audience (for example, annual declarations of national plutonium inventories under the Guidelines for the Management of Plutonium). These layers of transparency often act together to promote trust and confidence.

However, a balance always needs to be struck between the need for more transparency and the cost, in financial, institutional and strategic terms, of meeting the demand for information. There will always be demands for transparency that are not met, sometimes because there is good reason for opacity. One example is continued lack of transparency about physical protection measures whose effectiveness depends on secrecy. In other instances the capabilities and wherewithal to provide transparency may not be available, even where there is a will to provide it. Transparency is therefore what economists call 'satisficing', doing what is necessary to meet multivalent and sometimes conflicting demands for information, bearing in mind the basic objective that is being sought through transparency.

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The second aspect of transparency is: *what do they see*? Completeness, accuracy, timeliness and verifiability are key criteria for judging the quality of information that is made available through transparency measures. A range of options is available, depending on what is appropriate and feasible. With regard to nuclear materials transparency, the most demanding standards have been laid down by the IAEA's Standing Advisory Group on Safeguards Implementation (SAGSI). SAGSI criteria set out the level of accuracy and the periodicity with which nuclear materials accounts must be reported and verified to the IAEA. The criteria represent an international technical consensus about the standard of knowledge about fissile materials inventories which is required to be confident that no safeguarded material is being diverted for non-peaceful purposes.[2]

There are also different ways of revealing information about nuclear policies, capabilities and inventories, and often these are deployed together. Broadly speaking there is a sliding scale of transparency, including:

- *a statement of intent*, such as the declaration of a moratorium on further fissile material production for weapons purposes;
- *the provision of information on stocks and facilities*, such as an initial inventory, a facilities list or regular fissile material mass-balance accounts to safeguards agencies; and
- *the verification of information*, this includes a wide range of possibilities — from highly specific bilateral inspection arrangements of storage facilities containing fissile materials removed from nuclear weapons, to generalized policies of openness where the general public may be permitted to view nuclear facilities such as spent nuclear fuel ponds.

Complete transparency would entail each of these three modes of transparency operating together. This is rarely achieved. Typically, transparency is partial. Transparency also evolves. Frequently, limited transparency is sought when states are embarking on a new arms control venture, partly because there is insufficient trust or experience to achieve more extensive transparency. As a measure or regime matures, demands may increase along with an increasing willingness and capacity to share information. By the same token, excessive demands for transparency can damage arms control initiatives by raising political and bureaucratic costs of participation.

The Scope of Transparency about Fissile Materials

In our context, nuclear transparency is concerned with providing information about fissile materials, nuclear facilities, and industrial and policy processes. It is just as important to know how much fissile materials a state possesses as to understand how it intends to use the material. In some situations large inventories of fissile materials are not regarded as posing a risk to other states (civil inventories of plutonium in the United Kingdom, for instance), whereas small inventories held by states flouting treaty regimes can be seen as posing profound risks to international security (the DPRK's small inventory of separated plutonium).

Materials and facilities of concern

The main materials of concern are isotopes of uranium and plutonium. Transparency measures cover primarily 'weapon-usable' materials that could be used to produce a nuclear explosive device. The exception is low enriched uranium (LEU). The list of fissile materials covered by transparency measures includes:

- LEU, containing 0.71–20% uranium-235;
- HEU, containing over 20% uranium-235;[3]
- Weapon-grade uranium (WGU), containing over 90% uranium-235;[4]
- Reactor-grade plutonium, containing over 18% plutonium-240;[5]

- Fuel-grade plutonium, containing 7–18% plutonium-240; and
- Weapon-grade plutonium, containing less than 7% plutonium-240.

Other forms of uranium, including natural and depleted uranium, are not typically covered because substantial additional technical effort would be required to put them into a form where they would be weapon usable.

The facilities covered under nuclear transparency measures are those which hold or process the six categories of material listed above. These include: nuclear reactors, uranium enrichment plants, nuclear reprocessing plants, nuclear fuel fabrication facilities (uranium and plutonium fuels for land-based and naval reactors), and spent fuel and fissile material stores. The most sensitive facilities, and those about which the highest standards of transparency are demanded, are those where the greatest access to 'direct-use' material exists. This includes enrichment plants (potential access to HEU), reprocessing and plutonium fuel fabrication plants (access to plutonium), and fissile materials stores (potential access to both HEU and plutonium). Nuclear facilities in all these categories exist in both military and civil domains. Transparency measures therefore exist, in principle, to cover all these activities, even where proprietary technology needs to be protected, as with centrifuge enrichment plants. Clear exceptions here are nuclear weapons stores that contain complete or dismantled weapon components. Transparency about these materials is highly limited since they contain militarily and proliferation sensitive information.

Transparency Measures

A simple taxonomy of nuclear transparency measures was proposed above: internal transparency, bilateral transparency, multilateral transparency and transparency to non-state parties. Moreover, a dividing line in nuclear transparency still exists between those programmes that are military (broadly opaque) and those devoted to the production of nuclear electricity and nuclear research (broadly transparent). This distinction is becoming more blurred, as nuclear arms reduction and disarmament processes unfold. Today it may be more correct to include a set of 'transitional' activities in which materials produced in military programmes are being moved into transparent and civil domains.[6] Many of the major innovations in nuclear transparency focus on this intermediate category of activities and materials.

Internal transparency

Material accountancy in NWS: Monitoring and measurement of fissile material stocks and flows has historically been less careful within weapon programmes than in civilian programmes, especially safeguarded programmes. In only three states can we be reasonably assured that accountancy systems are equally effective in military and civil domains (France, the United Kingdom and the United States). Inadequacies in the Russian system of materials accounts are well documented, and from 1994 onwards led to a wide range of bilateral and multilateral programmes to improve MPC&A at weapon production facilities and at the many research organizations connected to the Russian nuclear complex. The best known and by far the largest of these is the American Nunn-Lugar Program. Together the aim is to establish an effective and uniform system of materials accounting and control across all Russian nuclear activities. By 1998, 150 facilities had been identified at fifty-three sites, some two-thirds of which had been upgraded, with work proceeding on the remainder.

These assistance programmes have not entailed any transfer of information about fissile materials stocks to donor countries. Their objective has been to enable Russian authorities to achieve greater control, with the broader aim of giving extensive assurance that the risks of fissile material 'leakage' will thereby be minimized. Attempts by the United States to encourage increased reciprocal transparency over fissile materials in military programmes have been frustrated. Accounting practices in China, Israel, India and Pakistan are not well understood.

Self-auditing by NWS: To have any real military or political significance, the process of nuclear disarmament has to involve the irreversible reduction of nuclear weapon capabilities. The first step to date has been the destruction of delivery vehicles, but the next step must include the removal of fissile materials from military inventories. A comprehensive audit is a useful device to establish what has been produced, what needs to be retained to support military programmes (nuclear weapons and naval propulsion) and what can be removed from military inventories.[7] A formal initial inventory of nuclear materials would be a prerequisite of complete disarmament, a task performed by South Africa in the early 1990s when submitting itself to full NPT safeguards as a NNWS. Full accounts are also required of Iraq and the DPRK as NNWS parties of the NPT.

The 'Openness Initiative' of the United States was intended to provide an account of the scale, form and location of fissile materials acquired and used for military purposes. The results have been published in stages, with detailed reports on plutonium appearing in 1994 and 1996. Main findings on HEU are expected during 1999. All the reports have been made public. In this sense, the audience included both the government itself, and a wider national and international audience. A tacit aim of the exercise was to encourage other states to demonstrate reciprocity and to launch similar exercises. One of the most telling findings has been that the United States Department of Energy has found that its knowledge of fissile materials stocks in military programmes has been incomplete. In 1998, the British Government declared for the first time the scale of fissile materials held in its military inventories, and announced that it would publish in 2000 an '... initial report on defence fissile material production ...'. No similar commitments have been made by other states.

Bilateral transparency

Fissile materials disposition programmes: Both the Russian Federation and the United States have begun the process of building-down their huge nuclear weapon arsenals. To date, arms reduction agreements between the two sides have been concerned with limiting the number of delivery vehicles, but since the early 1990s there has been an accelerated programme of nuclear warhead dismantlement, producing large amounts of fissile materials no longer required for military uses. Indefinite storage of these in weapon-usable form was not deemed acceptable by either the Russians (who were keen to convert hard-won military assets to civil use) or the Americans (who feared that Russian material might fall into the wrong hands). First attempts at defining excess fissile materials stocks have therefore been made (and published),[8] and concerted programmes to render weapon material inaccessible by technical means were initiated. HEU is to be diluted down to LEU for use as fuel in commercial power reactors; while plutonium is planned to be immobilized in a radioactive form, either through use in mixed oxide fuel (MOX) in power reactors, or through direct encapsulation in a waste form. Given the huge quantities of material to be processed, weapon material disposition programmes are likely to take 10–20 years.

Agreement was reached in 1993 between the Russian Federation and the United States over the sale of 500 tonnes of HEU, to be partially blended down in the Russian Federation to LEU and transferred to the United States Enrichment Corporation for sale on world enrichment markets. A set of bilateral transparency measures were negotiated at the same time. These were to assure the American side that material being transferred had come from military programmes, and the Russian side that the material was being put to peaceful uses. This has been achieved through declarations, materials accounting and mutual inspection of facilities. Public reports of the progress of the HEU disposition programme have also been made available.

Few concrete steps have been taken so far in plutonium disposition. This is partly because of the greater technical and commercial difficulties involved. Technical issues have been dealt with through close cooperation among the Russians, the Americans and a number of other states, including France, Germany, the United Kingdom and Japan. For the United States, the aim has been to pursue a 'dual-track' approach including both the MOX and the waste route. Interest among all the other parties has been limited to the use of plutonium released from weapons as MOX fuel. The process of technical engagement has not produced greater transparency about fissile material stocks, but has built confidence about industrial approaches and intentions on both sides.

Transfers of weapon-usable material: Transfers of weapon-usable materials (technically known as special fissionable and source material) and technology between countries are covered by safeguards arrangements described below.[9] For international transfers of certain types of material there are additional requirements for bilateral transparency. For instance, transfers back to Japan of plutonium separated from Japanese spent nuclear fuel at European commercial reprocessing facilities are covered under the United States-Japan Nuclear Cooperation Agreement (1992). This specifies a list of facilities where such plutonium can be processed into MOX fuel and recycled, and obliges Japan to justify on commercial grounds the use of plutonium. These transfers are also covered under a political cooperation agreement between European Union countries, which requires Japan to provide a clear plan for the storage, handling and use of plutonium that is returned to it. All these exchanges of information are aimed at providing assurances of peaceful use beyond those already provided by the implementation of international safeguards.

Multilateral transparency

Moratoria on fissile materials production: A weak form of transparency over military fissile material policies is represented by the declarations of moratoria on the production of fissile materials for nuclear weapon purposes by the United States, France, the United Kingdom and the Russian Federation. The American declaration was first made in 1993, the others came in 1995 at the NPT Review and Extension Conference. Without providing direct transparency over stocks, these declarations confirmed the basic policies of these states to limit their nuclear capabilities. They can also be regarded as precursors to a Fissile Material Cut-off Treaty, which would see the extension of transparency over fissile material inventories in both NPT and *de facto* NWS.

International nuclear safeguards (NPT and non-NPT): International safeguards have two objectives: to provide confidence that fissile materials in civil nuclear fuel cycles, or removed from military nuclear programmes, are not diverted for military purposes; and to detect clandestine nuclear production activities. Safeguards are applied only to materials in the civil domain. They are implemented by civilian international safeguards agencies, whose function is to verify that states are meeting peaceful use obligations set down in international law (the NPT, the Euratom Treaty, the Treaty of Tlatelolco, and the Brazilian-Argentine Nuclear Cooperation Agreement). All safeguards systems have essentially the same components:

- a complete initial inventory of fissile materials;

- an up-to-date list of facilities at which these materials are produced, stored and used;
- a 'national system of accounts' through which states monitor changes in fissile materials inventories;
- regular reports to the safeguards agency about inventory changes;
- regular inspections to verify these reports; and
- the use of seals and monitoring devices at nuclear facilities.

All information transmitted to the safeguards agency or collected by it through inspections and monitoring devices remains confidential, and is unavailable to other states. Safeguards therefore represent a very high level, but specific, form of nuclear transparency.

Two types of safeguards systems operate today: the global (NPT), and the regional (Euratom and the Argentine-Brazil Agency for Accounting and Control of Nuclear Materials). NPT safeguards are applied to all states parties to the treaty. However, full-scope safeguards, under which all nuclear activities in a state are covered under the terms of a standard safeguards agreement (INFCIRC/153) negotiated with the IAEA, apply only to NNWS.[10] NWS were not obliged to conclude safeguards agreements with the IAEA. However, each of them agreed under so-called 'voluntary offer' safeguards agreements to place certain facilities on a 'facilities list' that could be designated for inspection by the IAEA. In practice, few facilities have been designated under these agreements, so that the coverage of NPT safeguards in NWS has been extremely limited. Moreover, NWS have retained the right to withdraw fissile materials from safeguards. Unlike NPT safeguards in NNWS, which are permanent and unconditional, NPT safeguards in NWS are impermanent and conditional.

Partial IAEA safeguards, entailing inventory reports and inspections, are also applied under pre-NPT arrangements (INFCIRC/66-type safeguards) in non-NPT states like India, Pakistan and Israel. Under these agreements safeguards are applied to individual facilities, rather than the total system of plants.

The NPT safeguards system has been reformed and strengthened during the mid-1990s under the '93+2 Programme'. New measures flowing from this programme aimed specifically at the detection of clandestine nuclear activities in NPT NNWS, and were approved by the IAEA Board of Governors in 1995 and 1997. They include two powerful new transparency measures: 'enhanced declarations' and greater access to sites by IAEA inspectors. Under enhanced inspections the IAEA will collect information about a wider range of materials, facilities and activities, and be able to deploy new verification techniques such as environmental monitoring. The scope and intrusiveness of inspections has also been broadened to include sites and facilities not on available lists, as well as unannounced challenge inspections.[11]

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Euratom safeguards applied in the European Union (EU) are based on a different principle than NPT/IAEA safeguards. Under the Euratom treaty, all nuclear materials are formally owned by the Euratom Supply Agency. All non-military fissile material, including that in the two European NWS, is subject to Euratom safeguards. Operators of all non-military nuclear facilities provide nuclear inventory information to the Euratom Safeguards Agency, and are subject to routine inspection. Amongst the NWS, Britain and France offer a greater degree of transparency than the other actual and *de facto* NWS.

Trilateral initiatives to bring weapons materials under safeguards: Having voluntarily begun to remove fissile materials released from nuclear weapons out of military inventories and having declared moratoria on future production, the next step in making irreversible the 'civilianization' of former military stocks is to bring them under international safeguards. Under Euratom safeguards within the EU the apparatus to achieve this is already in place, since all non-military material must be placed under safeguards. In the United States and the Russian Federation, new arrangements need to be made since existing NPT 'voluntary offer' safeguards agreements are not regarded as being appropriate. A trilateral initiative among the United States, the Russian Federation and the IAEA began in September 1996 to investigate technical, legal and financial options. The Russian Federation and the United States have both committed themselves to the application of IAEA safeguards, expected to be mandatory and permanent, on excess weapons materials as soon as practicable. They are also expected to waive the right of withdrawal from safeguards.

Plutonium management guidelines: Despite the application of safeguards, physical protection measures and the regulation of safety and environmental hazards posed by the civil handling and use of plutonium, confidence in these activities has been low. During the 1990s, new voluntary transparency measures related to plutonium have been devised by the group of nine countries most involved in civil plutonium use, which have their origin in international discussions during the 1970s and 1980s about International Plutonium Storage.[12] The outcome, announced in late 1997, was a set of Guidelines for the Management of Plutonium (INFCIRC/549) under which states agreed to publish:

- statements of national strategy for nuclear power and the nuclear fuel cycle;
- annual statements of holdings of non-military separated plutonium; and
- annual statements of holdings of non-military plutonium contained in spent nuclear fuel.

These are public documents available through the IAEA, and the first set of national statements was made available at the end of 1998. Similar, though more complete, declarations of plutonium inventories have been made by the Government of the United Kingdom since 1984.

Extending the Scope of Transparency

The development of nuclear transparency has accelerated significantly during the mid-1990s. New mandatory and voluntary measures have been devised under which states provide information about fissile stocks to other states, to third party international organizations and to the public. The aim of this denser fabric of transparency is to continue to give assurance that treaty obligations are being met, and to demonstrate good intentions and goodwill. At the same time, there continues to be a demand for ever greater transparency. In particular, there is a preference for formalized forms of transparency applying to the widest range of nuclear materials.[13] There is, in principle, no limit to the amount of information that might be made available — indeed, we know from other areas of public life that the hunger for information only grows as more comes to be known. For reasons of both security and legitimacy, some of these demands will need to be met.

Table 1 provides an overview of transparency measures currently applied to different categories of fissile materials stocks. It also gives an estimate of the scope of international safeguards across these different inventories, showing the great variance that exists. If the 'gold standard' of nuclear transparency is the application of nuclear safeguards, it is clear that there is still a long way to go. Two major shifts are needed, assuming that materials in weapon inventories will always remain

Table 1. Transparency measures applied to fissile materials

a. Includes separated plutonium and HEU.
b. Euratom safeguards applied in Britain and France.

outside mandatory transparency. First, safeguards need to be applied more consistently in NWS on both military and civil inventories. Second, greater quantities of materials released from dismantled weapons need to be designated as excess and also brought under safeguards. These kinds of developments would not, of course, reduce the need for additional voluntary forms of transparency.

However, it would be wrong to conclude that the extension of transparency is inevitable or always linear. There remain many areas of military and civil nuclear activity where transparency is still resisted or contested. For instance, very little is known about nuclear programmes in China, India, Pakistan and Israel, and high degrees of uncertainty still exist around estimates of Russian fissile material inventories.

There is also a paradox about transparency in that there appears to be a link between its desirability and its value. Transparency is often most valuable where it is least attainable, and conversely is most attainable where its value has decreased. Almost by definition, states and other organizations hold most secret that which is of most value to them. One way of interpreting the increasing scope and density of transparency about nuclear materials may therefore be that states are increasingly willing to make this concession because their own interests have moved on. This is not to underplay the vital importance of the continued extension of nuclear transparency, but to seek to provide an explanation for why it may now be achievable in some places.

Notes

1. Plutonium and highly enriched uranium (HEU) are the materials out of which all nuclear explosive devices are produced.
2. Even these standards of transparency are not universally regarded as providing adequate confidence, as is borne

out by Israel's persistent criticism of IAEA safeguards.

3. This is also defined as weapon-usable since this material can support self-sustaining nuclear fission.
4. This is the grade of uranium normally used in the production of nuclear warheads.
5. All grades of plutonium can be used to produce nuclear fission, and hence a nuclear explosion. However, nuclear weapon designers typically prefer plutonium rich in the isotope plutonium-239. Higher numbered isotopes are more difficult to handle, so that the proportion of the most common of these, plutonium-240, is used to define the quality of plutonium.
6. See W. Walker and F. Berkhout, *Fissile Material Stocks: Characteristics, Measures and Policy Options*, UNIDIR Research Report, Geneva, in press.
7. There is a striking difference between the attitudes of the United States and the Russian Federation in this regard. While the United States has sought to produce a comprehensive account of historical fissile material production, the Russian Federation has so far failed to produce such an account.
8. The United States has so far declared 52 tonnes of plutonium and 165 tonnes of HEU excess. The United Kingdom has also declared that 4.4 tonnes of plutonium in its military inventory is excess to requirements, including 0.3 tonnes of weapon-grade material.
9. Under the NPT all transfers to NNWS are covered by the obligation to apply safeguards. This requirement was generalized in 1992 when these transfers were made conditional on importing NNWS bringing all fissile materials under IAEA safeguards (full-scope safeguards).
10. NPT safeguards are applied in EU Member States that are NNWS under the 153-equivalent INFCIRC/193.
11. These reforms are being implemented under a new protocol concluded in 1997 and designated INFCIRC/540.
12. Belgium, China, France, Germany, Japan, the Russian Federation, Switzerland, the United Kingdom and the United States.
13. Especially in countries already subject to stringent transparency requirements (NPT NNWS).

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The Costs of Disarmament

In order to present the cost-benefit analysis of disarmament, UNIDIR proposes to take key countries as examples and carefully research what their commitments to disarmament treaties means to them in terms of financial and resource costs. In addition, the project will try to ascertain what each country perceives are the benefits brought to them through their participation in the agreements and whether there is consensus that there is a net gain to the state in question. The aim of the project is to achieve a better understanding of the costs and benefits of disarmament agreements with a view to assisting policy-makers to decide how money is spent on such commitments, which budget lines are best structured to handle such spending and how states could approach this aspect of negotiations in the future.

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Forming a North-South Alliance to Address Current Problems of Biological Warfare and Disarmament

The first conference of this project, "Biological Warfare and Disarmament: Problems, Perspectives, and Possible Solutions," held at the Palais des Nations in July 1998, brought together people with a wide range of academic and career backgrounds — scholars in international law, political science, economics, history and the biological sciences, members of non-governmental organizations committed to disarmament and the peaceful development of the biological sciences, and specialists on the Biological Weapons Convention — to address current dimensions of the biological warfare problem. A goal of the conference was to achieve broad geographical, and especially non-western representation

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and to provide a space where non-western perspectives could be seriously presented and discussed. The conference ranged broadly over the history and politics of biological warfare and disarmament, encompassing such questions as the recent history of biological warfare, the impacts of the United Nations Special Commission inspections of Iraq and their implications for the biological weapons regime, the influence of the pharmaceutical and biotechnology industries on the regime, and the role of nuclear weaponry in shaping the regime. These questions are also explored in a forthcoming symposium, drawing on selected conference papers, to be published in the March 1999 issue of *Politics and the Life Sciences*. More general legal, political and social dimensions of the biological warfare problem will be addressed in a book in progress. The project is supported by the John D. and Catherine T. MacArthur Foundation, the Ford Foundation, the New England Biolabs Foundation and the University of Michigan.

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Peace-keeping in Africa: Meeting the Growing Demand

This project examines current efforts to develop African capacities to undertake peace-keeping and peace enforcement operations. The project will analyze the reasons for the United Nations Security Council's growing tendency to sub-contract the promotion of peace and security to others and will pay particular attention to regional and sub-regional organizations. It will also review Western and African attempts to make "burden-sharing" work and propose policies to strengthen peace-keeping in Africa. Particular attention will be paid to capacity-building efforts of the United Nations and regional and sub-regional organizations. UNIDIR will publish the project's conclusions as a monograph.

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South Asia Discussion Meetings

On 7 and 8 September 1998, UNIDIR held a private, off-the-record meeting on The Implications of South Asia's Nuclear Tests for the Non-proliferation and Disarmament Regimes. This "track one and a half" meeting was designed to address the needs of policy makers — governmental and non-governmental agents — in their assessment of the impact of the nuclear-weapons tests carried out by India and Pakistan in May 1998. The governments of Australia, Denmark, Italy, Norway, New Zealand and the United States generously sponsored the meeting. A full summary of the proceedings has been produced by UNIDIR and is also available online.

In order to facilitate dialogue about the ways that trust can be built within the relationships in South Asia, UNIDIR held a private, off-the-record discussion meeting on 23 and 24 November 1998. Experts and practitioners from Asia, Asia-Pacific, Africa, Europe, Latin America, the Middle East and North America participated in this meeting, which considered the current situation of trust and confidence-building measures (TCBMs) in South Asia, experiences from other regions, and looked at ways that TCBMs in South Asia could be further strengthened and developed. A full summary is currently under preparation.

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The Transfer of Dual-Use Outer-Space Technologies: Confrontation or Cooperation?

The right of every state to develop outer-space technologies, such as launching capabilities, orbiting satellites, planetary probes or ground-based equipment, is in principle unquestionable. In practice, however, problems arise when technology development approaches the very fine line between civil and military applications, largely because most of the technologies can be used for dual purposes. This dichotomy has raised a series of political, military and other concerns that affect the transfer of outer-space technologies in different ways, particularly between established and emerging space-competent states. Accordingly, for many years several states have sought ways to curb the transfer of specific dual-use outer-space technologies, specifically launcher technology, while still allowing some transfer of these technologies for civil use. The results of this research will be published by UNIDIR.

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Study Group on Ammunition and Explosives

The Panel of Governmental Experts on Small Arms, which was established on 12 December 1995 by General Assembly resolution 50/70 B, delivered its report to the Secretary-General in July 1997. One of the recommendations of this report stated that "The United Nations should initiate a study on the problems of ammunition and explosives in all their aspects." Following this recommendation, a Study Group on Ammunition and Explosives was established by the Secretary-General pursuant to operative paragraph 3 of resolution 52/38J on "Small Arms". This group, chaired by Ms. Silvia Cucovaz (Argentina) held its first meeting at the invitation of the Department of Disarmament Affairs in New York on 27 April–1 May 1998. Two of the eight members of the Study Group are from UNIDIR: Dr. Christophe Carle and Lt.Col. Ilkka Tiihonen.

The Group's task is to assist in the preparation of the Secretary-General's report, to be submitted to the 54th session of the General Assembly. The final report is expected to be ready in summer 1999 prior to the opening of the General Assembly.

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Uses of Commercial Satellite Technology in the Middle East

UNIDIR and the Cooperative Monitoring Center at Sandia National Laboratories recently co-hosted a workshop on the potential uses of commercial satellite imagery for promoting peace and development in the Middle East. The participants explored three main areas where remote sensing technology might be employed: arms control, economic development, and environmental and natural resources.

A monograph summarizing the trends of the discussions and giving an analysis of the potentials of remote sensing technology for building peace and economic development in the Middle East is underway.

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Peace-building and Practical Disarmament in West Africa: Stimulating National Research

Under the heading of disarmament, development and conflict prevention, UNIDIR is currently developing a number of initiatives to promote peace and security in West Africa. UNIDIR's work in this region began with a conference co-hosted with the United Nations Development Programme (UNDP) in Bamako, Mali, in November 1996. The Government of the United Kingdom has generously contributed to this project.

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UNIDIR Handbook on Arms Control

UNIDIR is producing a handbook that will explain the major concepts and terms relating to arms control. The handbook will be used as both a primer for an audience with limited familiarity with arms control and as a reference for students, scholars, diplomats and journalists who are more experienced in arms control matters.

The handbook will be organized as a thematically structured glossary of approximately 200 terms relating to arms control. Each term is situated within its wider context so that, on the one hand, a specific term can be looked up quickly, and on the other hand, an entire issue can be covered. Cross-references to other terms and concepts will point the reader to relevant related issues. The researcher designing and drafting the handbook will be assisted by an editorial committee consisting of regional and arms control experts.

The handbook is expected to be published in 1999, in English and Arabic. It might be translated into other languages at a later stage.

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Geneva Forum

Together with the Programme for Strategic and International Security Studies of the Graduate Institute of International Studies and the Quaker United Nations Office, UNIDIR organizes an ongoing discussion series called Geneva Forum. Geneva Forum is an occasional seminar held at the Palais des Nations that addresses contemporary issues in arms control and disarmament. The series targets the local missions and organizations in an effort to disseminate information on a range of security and disarmament topics.

The series seeks to act as a bridge between the international research community and Geneva-based diplomats and journalists. Thanks to the generous support of the Government of Switzerland, Geneva Forum focuses on issues related to small arms and light weapons. Invited speakers will deal with specific thematic and/or regional dimensions of the issue.

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PUBLICATIONS

Fissile Material Stocks: Characteristics, Measures and Policy Options

In 1998, on the basis of the Shannon Mandate, the Conference on Disarmament (CD) established an ad hoc committee for negotiating a fissile materials treaty. The treaty is intended to achieve a ban on the production of fissile materials for military purposes in a non-discriminatory, multilateral and internationally verifiably manner. Stocks of fissile materials have accrued transnationally due to armament and disarmament processes, as well as to civil uses of nuclear power. However, very little is known in the public domain about the nature, size and whereabouts of such stocks, and the complexities surrounding their regulation and control. UNIDIR's report on fissile material stocks seeks to begin to redress this problem by providing factual background information on all of these important matters. The report categorizes and quantifies fissile material stocks, and examines the measures which have heretofore been developed regarding their control and management. The report also includes an overview of broad policy options available to states in addressing the stocks issue, which could prove valuable in informing negotiations in the CD.

Fissile material stocks: function, scale and distribution

Characterization by type of inventory

The scale, type and location of fissile material stocks

Measures relating to fissile material stocks: recent developments

Military inventories: continuing absence of international regulation

Transitional inventories: towards regulation and disposition

Civil inventories: the extension of transparency

Policy strategies and options

Stocks and the FMT: possible diplomatic approaches

Possible measures for reducing risks posed by fissile material stocks

Fissile materials and their production processes

International safeguards and physical protection

William Walker & Frans Berkhout

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Sensors for Peace

United Nations peace operations have a tradition of several decades, and their scope and importance has increased markedly since the end of the Cold War. Peacekeeping operations, both of the traditional and the extended type, comprise monitoring tasks as a central part of their mandates. Agreements or resolutions, whether they demand withdrawal behind a cease-fire line, keeping a buffer zone demilitarized, or banning heavy weapons in control zones or safe havens, require that compliance is checked reliably and impartially. The more comprehensive the monitoring, the more likely the compliance. In practice, however, monitoring duties often require the surveillance of such large areas that United Nations peacekeeping units cannot provide continuous coverage. Thus, peacekeeping personnel are permanently deployed only at control points on the roads or areas deemed most sensitive. Minor roads and open terrain are covered by spot-check patrols. This creates many opportunities for infractions and violations.

Unattended ground sensor systems allow all this to change. Unattended ground sensors are suited to permanent, continuous monitoring. They can be deployed at important points or along sections of a control line, sense movement or the presence of vehicles, persons, weapons, etc. in their vicinity and signal an alarm. This alerts peacekeepers in a monitoring centre or command post, who can send a rapid-reaction patrol immediately to the site to confront the intruders, try to stop them, or at least document the infraction unequivocally.

Unattended ground sensor systems generally have not been used in peace operations. Thus, the wider introduction of unattended ground sensor systems in future United Nations peace operations requires fresh study from operational, practitioner, system design and legal perspectives. *Sensors for Peace* is an excellent first look at this timely issue.

Jürgen Altmann, Horst Fischer and Henny J. van der Graaf
Editors

Sales No. GV.E.98.0.28
ISBN 92-9045-130-0

Non-Offensive Defence in the Middle East?

Non-offensive defence (NOD) emerged as a proposed remedy to the military security problems of East and West during the latter part of the Cold War. Grounded in the notion of "cooperative security", NOD is premised on the postulate that states in the international system are better off pursuing military policies which take account of each other's legitimate security interests than they are in trying to gain security at each others' expense. Competitive military policies which seek to achieve national security through a build-up of national military means, may well be counter-productive and leave states more insecure. Seeking to procure national military security through a build-up of national armaments raises suspicions as to the purpose of these armaments, which in turn trigger countervailing armament efforts which ultimately lower the level of security for all. By making the defence of domestic territory the sole and clear objective of national military policies, NOD aims to strike a balance between the imperatives of ensuring adequate national military security and of avoiding provocation.

NOD aims towards national military defences strong enough to ensure adequate national military security, but not strong enough to be seen as threatening by others. The provision of adequate yet non-threatening military defence can be highly useful in a region such as the Middle East where political and military confrontations are inextricably linked, and where political settlement in the absence of military security is inconceivable. In the Middle East, NOD could reduce prevailing military tensions and open the way for broader political arrangements on the future of the region.

The introduction of NOD in the Middle East, would not require that all Middle Eastern states adopt the same NOD model. Rather, each Middle Eastern state can select the particular NOD model most suitable to its requirements. Most NOD models are suitable for most Middle Eastern states, though particular models may be better suited to different states.

Bjørn Møller, Gustav Däniker, Shmuel Limone and Ioannis A. Stivachtis

Sales No. GV.E.98.0.27
ISBN 92-9045-129-7

The Implications of South Asia's Nuclear Tests for Non-proliferation and Disarmament Regimes

On 7 and 8 September 1998, UNIDIR held a private, off-the-record meeting on *The Implications of South Asia's Nuclear Tests for the Non-proliferation and Disarmament Regimes*. This "track one and a half" meeting was designed to address the needs of policy makers — governmental and non-governmental agents — in their assessment of the impact of the nuclear-weapons tests carried out by India and Pakistan in May 1998. The governments of Australia, Denmark, Italy, Norway, New Zealand and the United States generously sponsored the meeting.

More than fifty people from over twenty-five countries attended the conference. Each participant attended in his or her personal capacity as an expert and not as a representative of a country or a NGO. At the end of this two-day meeting, there was general agreement among participants that neither India nor Pakistan had enhanced its own security or international status by conducting the tests, but that the risk of nuclear war in the region is now greater. Also, it was recognized that the NPT and the CTBT had been in difficulty prior to the tests, although they remained the best solutions available to reduce potential for further conflict and therefore remained crucial. Finally, many participants expressed their concern that if India and Pakistan were rewarded in any way for demonstrating their nuclear capabilities, this may cause some NPT members to reassess their membership in the regime.

International response to the nuclear tests in South Asia was inadequate: there is a need for more coherent and collective action. Participants focused on practical suggestions to policy makers to reduce the risk of war; to save the non-proliferation and nuclear arms control regimes; and to anticipate the effects of the tests on areas of regional tensions, particularly the Middle East.

GE.99-00415
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A Peace of Timbuktu: Democratic Governance, Development and African Peacemaking

Mali is admired for two recent accomplishments. The first is the country's transition to democracy, which took place in 1991–1992. This effort included the overthrow of Moussa Traoré's twenty-three year military dictatorship on 26 March 1991 — a process of military and civilian collaboration which fostered national reconciliation, a referendum for a new constitution, and elections which brought to power Mali's first democratically elected president, government and legislature. The second achievement is the peacemaking between the Government of Mali and the rebel movements in the northern part of the country: this process successfully prevented the outbreak of civil war and presents useful lessons in preventive diplomacy for the international community. The peacemaking culminated in a ceremony known as the Flame of Peace, when rebel weapons were incinerated in Timbuktu on 27 March 1996. This study of the events surrounding the uprisings in the North of Mali and the measures which restored peace (and those which will maintain it) is the result of a collaboration between the United Nations Development Programme and the United Nations Institute for Disarmament Research.

This peace process was remarkable for the way in which the United Nations agencies were able to help, discreetly dropping oil into the machinery of peacemaking. For a cost of less than $1 million, the United Nations helped the Malians to avoid a war, and lit the Flame of Peace. With less than $10 million, the United Nations became the leading partner of Mali's Government and civil society, in peace-building, disarming the ex-combatants and integrating 11,000 of them into public service and into the socio-economy of the North through a United Nations Trust Fund. The experience shows that not only is peacemaking better than peace-keeping, but that it is much cheaper.

A Peace of Timbuktu includes in-depth coverage of the following topics:

- Mali's History and Natural Environment
- The Build-up to the Crisis in Northern Mali
- The Armed Revolt 1990–1997
- Peacemaking and the Process of Disarmament
- The International Community as a Catalyst for Peace
- Ensuring Continued Peace and Development in Mali
- The Flame of Peace Burns New Paths for the United Nations

United Nations Secretary-General Kofi Annan has written the preface. The book includes maps, texts of relevant documents and laws, and a bibliography, as well as photographs by the authors and peace drawings by the children of Mali.

Robin Edward Poulton and Ibrahim ag Youssouf

Sales No. GV.E.98.0.3
ISBN 92-9045-125-4
Soon to be available in French

Nuclear-Weapon-Free Zones in the 21st Century

The establishment of nuclear-weapon-free zones (NWFZs) through the initiative of regional parties, approved by the United Nations General Assembly, and endorsed by the relevant external states, is an important contribution to non-proliferation, disarmament and, above all, to international security.

Jointly with OPANAL (The Organization for the Prohibition of Nuclear Weapons in Latin America and the Caribbean) and the Government of Mexico, UNIDIR convened an international seminar on "Nuclear-Weapon-Free Zones in the Next Century" in Mexico City on 13–14 February 1997 — the thirtieth anniversary of the Treaty of Tlatelolco's opening for signature. This book analyzes the role of the Treaty of Tlatelolco as the first effective expression of a NWFZ in a densely inhabited part of the globe. It also covers other NWFZs (existing or proposed). The relationship between NWFZs and peace processes, as well as cooperation among existing NWFZs, is also noted.

Péricles Gasparini Alves and Daiana Belinda Cipollone
Editors

English	Sales No. GV.E.97.0.29	ISBN 92-9045-122-X
Spanish	Sales No. GV.S.97.0.29	ISBN 92-9045-124-6

Increasing Access to Information Technology for International Security

The European security landscape is undergoing a profound transformation at present, and there is an increasing need to improve mutual understanding of regional security issues in a rapidly changing world. Institutes and related organizations working in the field of international security have an important role to play in this regard.

This book contains a forward-looking appraisal of how information technology can best serve institutes and the security dialogue. It addresses issues such as how to promote concrete cooperation between research institutes in Europe and North America. Of particular importance is the appraisal of present and prospective demands for cooperative ventures between and among institutes in Europe, the United States and Canada. It also provides insight on how to put together intellectual, human, material and financial resources to foster cooperation, notably in the identification of partners, information needs, connectivity issues and fund-raising strategies. In this respect, a number of innovative recommendations are made in a plan of action to increase cooperation in the late 1990s and well into the next millennium.

Assessing Partnership Initiatives — *Andreas Wenger & Stephan Libiszewski*
Identifying the Needs of International Organizations — *Anthony Antoine & Gustaaf Geeraerts*
Increasing Interregional Exchanges and Partnerships — *Seyfi Tashan*
Information Needs and Information Processing in International Security — *Gerd Hagmeyer-Gaverus*
A New Approach to Conflict Prevention and Mediation Processes — *Albrecht A. C. von Müller*
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