VIEWPOINT: VERIFYING A FISSILE MATERIAL PRODUCTION CUT-OFF TREATY

by Victor Bragin, John Carlson, and John Hill

The Conference on Disarmament (CD) in Geneva has recently decided to establish an Ad Hoc Committee for the negotiation of a fissile material cut-off treaty (FMCT). Such a treaty would prohibit the production and, most likely, the acquisition of fissile material for nuclear weapons or other nuclear explosive devices. This decision represents an important opportunity. An FMCT would serve both nuclear disarmament and nonproliferation objectives, as a logical complement to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the Comprehensive Test Ban Treaty (CTBT).

Successful achievement of an FMCT would be an important step towards the goal of eliminating nuclear weapons[1]—an objective of the highest priority for Australia.[2] The FMCT and CTBT together would place a quantitative cap on the amount of nuclear material available for weapons and a qualitative cap on nuclear weapon design development, thereby constraining further expansion of nuclear weapons programs. By signaling each state's willingness to accept such constraints, an FMCT would also provide greater confidence to the nuclear weapon states (NWS) as they consider and implement further reductions in their nuclear arsenals.

The recent Indian and Pakistani nuclear tests have given an FMCT more immediate urgency as well. An FMCT would provide the South Asian rivals with an opportunity to avoid a disastrous arms race and consequent regional instability. It also offers a promising possibility to bring the "threshold states"[3] into the global nuclear nonproliferation and disarmament regime.

This essay discusses factors that would affect the scope of verification under an FMCT and makes recommendations based on the negotiability, credibility, and cost-effectiveness of alternative options. Verification has the potential to be a major stumbling block in the negotiations. Under the NPT, non-nuclear weapon state (NNWS) parties already accept full-scope safeguards on their fissile materials, but the five NWS and three threshold states do not have comparable obligations. An attempt to use an FMCT to bring the latter states under identical arrangements to the NNWS would probably lead them to reject such a treaty and would impose unnecessarily high resource demands even if accepted. The goal of this essay, therefore, is to propose an effective verification regime that would be both realistically negotiable and financially feasible.[4]

We assume that any eventual FMCT agreement will focus on future production. Though some states have sought to include restrictions on stocks of fissile material existing at the time of entry into force, we believe most key states now accept that the only negotiable treaty is one that deals primarily with future production. Given this assumption, we propose a *focused* approach to verification. This approach recognizes that the objective of verification under an FMCT can be drawn more narrowly than under the NPT, which provides an opportunity to conduct credible verification while containing the cost. Under a focused approach, safeguards would be applied only to those facilities and materials that are most sensitive in proliferation terms, namely those facilities that actually could be used to produce fissile material for nuclear explosive devices. This would encompass all facilities with reprocessing and enrichment capabilities, and certain products of such facilities.

Although we assume an FMCT will focus on future production, we believe any such accord should also include a verification mechanism to provide assurance that international transfers from pre-existing stocks are not

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made for proscribed purposes, and a provision on irreversibility, i.e., some assurance that once fissile material has been brought under safeguards it cannot be subsequently withdrawn for proscribed purposes. We therefore consider in this essay how a verification regime might address these other objectives as well.

Finally, we propose that the International Atomic Energy Agency (IAEA) should be charged with verifying compliance with an FMCT. This seems the most likely outcome, since the IAEA already has similar responsibilities with respect to verification of compliance with the NPT and other arrangements, including almost thirty years experience under the NPT alone. It seems unlikely that any other organization, existing or new, could be so well placed to carry out credible and cost-effective verification under an FMCT.

After a brief review of how the FMCT idea has come onto the negotiating agenda, we outline what we predict will be the main features of the eventual treaty and indicate our own preferences on certain issues that could go either way. We then describe the verification provisions and related details that we believe would be most appropriate for such a treaty. Finally, we list some remaining technical issues that will have to be dealt with in the negotiations even if our basic approach is accepted. These include some problems for which we have no recommendations, in the hope that drawing attention to these potential obstacles to an agreement might stimulate creative proposals elsewhere.

NEGOTIATING HISTORY OF THE FMCT

The international community's aspiration for an agreement to terminate the production of fissile material for nuclear weapons has been demonstrated repeatedly. On December 16, 1993, the United Nations General Assembly (UNGA) adopted Resolution A/RES/48/75/L, which recommends "the negotiation in the most appropriate international forum 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."[5] In March 1995, the CD agreed by consensus to establish an Ad Hoc Committee with a mandate to negotiate an FMCT based on the 1993 UNGA resolution. In May 1995, the parties at the NPT Review and Extension Conference also agreed to seek "the immediate commencement and early conclusion" of FMCT negotiations.[6] This was widely perceived to be the second priority for future talks, behind only the CTBT.

While the prospects for an FMCT appeared to improve between 1993 and 1995, efforts to commence negotiations in the CD (which operates by consensus) were not successful at that time. Some states, especially India, insisted on linking FMCT negotiations to a time-bound or phased program for nuclear disarmament, a linkage other states, especially the NWS, would not accept. Another issue that prevented progress was whether to include existing stockpiles of fissile material in the scope of the negotiations.[7] Demands to do so came especially from states like Pakistan that feared being locked into an inferior position relative to a nuclear rival.

A breakthrough occurred recently in the aftermath of the Indian and Pakistani nuclear tests of May 1998, when Pakistan dropped its objections in the CD to the negotiation of an FMCT. India, always more positive towards an FMCT and worried by a decline in Non-Aligned Movement support for linkage with a time-bound program for nuclear disarmament, followed suit. Finally, Israel agreed to a U.S. request to allow negotiations to proceed. On August 11, 1998, the CD reached an important decision to establish an Ad Hoc Committee on an FMCT, thus opening the way to negotiations.

Predicted and Proposed Elements of an FMCT

In this section, we outline those features of a possible FMCT for which there is already sufficient support to expect agreement. We also propose additional measures to strengthen these core features that we believe to be negotiable as well, and indicate whether these are more likely to be accepted as part of the treaty or as separate understandings. We define both what would and what would not be prohibited under the FMCT we anticipate.

Proscribed Activities

An FMCT would prohibit the production and, we propose, the acquisition (i.e., by transfer) of fissile material for nuclear weapons or other nuclear explosive devices. Accordingly, upon entry into force, each state party would undertake:

- not to produce or acquire through other means fissile material for nuclear weapons or other nuclear explosive devices;
- not to use any fissile material that is subject to verification under the FMCT for nuclear weapons or other nuclear explosive devices;
- not to assist any other state in acquiring fissile mate-

rial for nuclear weapons or other nuclear explosive devices; and
• to produce or acquire fissile material for non-proscribed purposes exclusively under international safeguards.

Non-Proscribed Activities

We predict that an FMCT probably would not prohibit the following activities:
• retention of stocks of fissile material existing outside international safeguards at the time of entry into force;
• production of fissile material under international safeguards for electricity generation and other civil purposes;
• chemical reprocessing of irradiated material under safeguards as required for spent fuel management or safety reasons;
• tritium production for any purpose, including the use of tritium in nuclear weapons;
• production of fissile material for non-explosive military uses, including highly enriched uranium (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.

Although an FMCT almost certainly will not proscribe non-explosive military activities, there should be a requirement to verify that fissile material produced or acquired for such purposes is not diverted to proscribed purposes. This could be achieved through a provision along the lines of paragraph 14 of the IAEA's Information Circular (INFCIRC)/153, the model full-scope safeguards agreement applying to all nuclear material in NNWS parties to the NPT. Thus, a state would give the IAEA advance notification of its intention to use fissile materials subject to the treaty for non-explosive military applications, and the IAEA would carry out appropriate verification measures to provide assurance that those materials are not diverted from their declared use to the manufacture of nuclear weapons or other nuclear explosives, or for purposes unknown. The verification measures will have to be designed and implemented in such a manner as to respect the military sensitivity of such applications while at the same time providing credible assurance of non-diversion.

A Proposed Complementary Measure

Because we expect that an eventual FMCT may apply only to production for weapons or other nuclear explosives, we favor a complementary proscription of production of material near weapons grade *for any purpose*. Otherwise, a loophole that permits states to produce weapons-grade material for civil purposes will create a significant potential for rapid breakout. However, inclusion of this proscription in the FMCT itself might unduly complicate negotiations; for example, it might support an argument that the FMCT should itself be limited to weapons-grade materials. Such a limitation would seriously narrow the scope of the treaty. Accordingly, we suggest that the proscription of all weapons-grade production be adopted as a separate measure complementary to the FMCT.

We are not aware of any compelling reason why such a prohibition could not be agreed to by the parties to an FMCT. With respect to plutonium, we know of no legitimate civil requirement that could not be met by plutonium outside weapons-grade. By "production" of plutonium in this context, we mean separation through reprocessing. Where production of high-fissile plutonium is unavoidable, e.g., in fast breeder reactors, separation of such plutonium could be avoided through in-process blending with lower grade plutonium. On similar grounds, there is a strong argument for the proscription of plutonium isotope separation to obtain weapons-grade material. If there are limited research projects that require high-fissile plutonium, this material could be readily acquired from existing stocks without the need for further production.

As regards uranium at very high enrichment levels, existing stocks appear ample to meet possible research needs, and we support the U.S. effort to phase out HEU use in research reactors. While we recognize that some states need to use HEU of very high enrichment for naval propulsion, we wonder whether existing stocks are not also ample to meet any foreseeable requirements.

Treatment of Existing Stocks

The issue of how to treat past production of fissile material—pre-existing stocks—is a major theme in the current debate.[8] In the case of states that have accepted comprehensive safeguards under the NPT or other agreements, all their holdings of nuclear material are already subject to IAEA safeguards. The question is therefore whether restrictions and safeguards already applied to the NNWS would, under an FMCT, be extended to the NWS and non-parties to the NPT. Taken to the limit, to

apply an FMCT to all pre-existing stocks held by the NWS and threshold states would amount to instant disarmament, a desirable but unrealistic objective at this point in time. Even trying to find a compromise formula, perhaps involving partial stockpile reductions or extending full-scope safeguards to the NWS, could hopelessly complicate the negotiations. Thus, any FMCT agreement will almost certainly cap only future production, but leave past production in the NWS and threshold states outside safeguards.

Many states, however, believe this should not become a permanent state of affairs. In order to achieve agreement to an FMCT, it may well prove necessary for the participating states to agree in principle to a progressive process that would bring existing stocks within the treaty or a parallel convention or conventions. Because a specific commitment on timing has not been acceptable to the NWS, the best way to bring existing stocks under safeguards is through an evolving international legal framework. An FMCT would be an important part of this framework, but the framework would also incorporate other measures relating to the transparency, safe and secure management, and disposition of fissile material no longer required for defense purposes, as this material is released from military inventories as a result of the nuclear disarmament process.

For example, with a view to increasing the transparency and public understanding of the management of plutonium, several states have agreed recently to publish annual statements of their civil holdings of unirradiated separated plutonium.[9] This is an important first step to better transparency in the area of civil stocks of fissile material, which should be extended to HEU as soon as possible. We recommend that all stocks of purely civil unirradiated direct-use material[10] be brought under NPT or FMCT safeguards at the time of the FMCT's entry into force. This could be done by encouraging states to declare voluntarily a part of their fissile material produced prior to entry into force, to be subject to verification. We see no reason why most unirradiated weapons-grade material in non-sensitive form could not be placed under international verification arrangements in the near future.

Over the longer run, under the progressive process we envision, verification could also be applied to unirradiated weapons-grade material in sensitive form. Such material (e.g., pit components) is readily available for re-assembly and re-deployment, and will always remain under national control and physical protection. Eventually, we believe, bilateral and later multilateral verification arrangements should also be applied to these materials. In the meantime, because holding material in component form suggests that it is readily available for weapons, excess components should be disassembled as early as possible.

THE SCOPE OF VERIFICATION

The safeguards associated with an FMCT would have three purposes: verification, timely detection, and deterrence. First, an FMCT must include means to verify that fissile material is not produced or acquired 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. Second, an FMCT must allow timely detection of undeclared production or diversion of fissile material. Finally, FMCT safeguards must deter undeclared production or diversion by the risk of early detection.

Even if there is agreement on these goals, opinions are likely to differ about the scope of verification needed under an FMCT. The basic question is whether to seek a treaty with wide or focused verification. A treaty of wide scope would cover all nuclear facilities and material, except perhaps 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 production from those facilities.

For several reasons, it makes more sense to adopt focused rather than wide or comprehensive safeguards under an FMCT. First, the existence of sizable unsafeguarded stocks, produced prior to entry into force, will make it quite difficult to design, gain agreement to, and implement comprehensive safeguards. Holding out for comprehensive verification could therefore prevent agreement on a production cut-off, which is achievable now. In addition, the total cost might be more than the negotiating parties are willing to pay, as IAEA resources would have to be increased at least threefold to apply comprehensive safeguards.[11] Finally, we doubt the additional benefits gained from having verification of wide scope would be sufficient to justify the extra cost over a focused approach. For example, if the NWS and the threshold states join an FMCT, it will be because they

have decided that existing stockpiles are sufficient to meet their security needs. If so, they will have a limited incentive to divert safeguarded material or establish undeclared production, and focused safeguards should be adequate to deter such an unlikely course.

Once this more general choice is made, the precise scope of verification will depend on five basic parameters: the *definition of subject material*, i.e., categories of fissile material subject to the treaty; the *definition of production*, i.e., types of nuclear facilities covered by verification activities; the *starting point* of safeguards; the *point of termination* of safeguards; and *detection goals* and associated safeguards approaches. In the rest of this section, we present our recommendations for these FMCT parameters and summarize how a focused approach would operate overall.

Definition of Subject Material

We propose that only unirradiated direct-use material should be subject to verification under an FMCT. Such material includes: plutonium with an isotopic concentration of Plutonium-238 of less than 80 percent; highly enriched uranium containing 20 percent or more of the isotope Uranium-235; Uranium-233; any other unirradiated materials that may be designated as "special fissionable materials" by the IAEA Board of Governors; and any material that contains one or more of the foregoing. This definition excludes low-enriched uranium (LEU), and also plutonium, HEU, and Uranium-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," so that material which is only lightly irradiated, or where radiation levels have significantly declined over time, will be subject to verification.

Definition of Production

In accordance with the above definition of subject material, the following activities should be defined as "production of fissile material" under an FMCT: separation of plutonium, HEU, or Uranium-233 from irradiated nuclear material; recovery of plutonium, HEU, or Uranium-233 from active waste; increasing the abundance of the isotopes Uranium-235 or Uranium-233 in uranium through any isotope separation process; and increasing the abundance of the isotope Plutonium-239 in plutonium through any isotope separation process. Note that this definition excludes *nuclear* production, i.e., production of plutonium and Uranium-233 in nuclear reactors, critical assemblies, or through the use of any other intense neutron sources. 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.

We include plutonium isotope separation in the definition of "production" under an FMCT in order to cover the possibility of unsafeguarded production of weapons-grade plutonium from reactor-grade plutonium. An FMCT will especially need to cover this if, as we expect, existing stocks of separated reactor-grade plutonium, in those states that are outside comprehensive safeguards, are not covered by the treaty. However, as proposed above, we believe it would be even better to have a complementary agreement to proscribe plutonium isotope separation for any purpose, other than perhaps at a very small scale for research purposes, as an activity inimical to the object of an FMCT.

Starting Point of Safeguards

The starting point of safeguards under an FMCT should, in our opinion, be different from that of the INFCIRC/153-type comprehensive safeguards applied to NNWS under the NPT. We recommend that the fissile materials defined above become subject to verification under the FMCT when:

- they are acquired by transfer from another state;
- plutonium, HEU, or Uranium-233 contained in irradiated material (fuel assemblies or special targets) is introduced into a reprocessing plant or any other facility capable of separating subject material from fission products;
- plutonium, HEU, or Uranium-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.

Accurate definitions would have to be developed for each type of facility mentioned above, as the design information for them became available to the IAEA.

Point of Termination of Safeguards

We propose that fissile materials subject to verifica-

tion under an FMCT should cease being subject to such verification:

- upon transfer to another state;
- 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 Uranium-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 percent of the isotope Uranium-235); or
- upon a determination by the IAEA that the fissile material has become practicably irrecoverable.

Appropriate definitions would have to be developed for different types of material. In the case of transfers to another state, we recommend that the FMCT include procedures for advance notification of the IAEA about intended transfers of material safeguarded under the FMCT. The IAEA would verify the quantity and composition of the material before it is transferred out of the state, and the material concerned would then become subject to verification in the recipient state under the NPT or FMCT.

Verification Goals

The question here is whether it makes sense to use existing IAEA "significant quantities" (SQ) and timeliness criteria[12] in states that already have nuclear weapons. Some experts suggest that, because of the more advanced technological development of the NWS, more demanding (i.e., lower) values of SQ and the timeliness goal should be applied to them.[13] Others argue that, at the current stage of the disarmament process, the verification goals and evaluation criteria for the NWS could be based on the amount of fissile material remaining in their defense stockpiles.[14] Under this argument, the SQ value could be very high for now, because "a few more kilograms do not matter." This quantity would be lowered to the INFCIRC/153 value as NWS stockpiles diminished. Given the sensitivities aroused when treaties appear discriminatory, however, we disagree with proposals to make the verification goals for the NWS either stricter or looser than those for the NNWS. We thus favor use of the same verification goals established in NPT safeguards for verification under an FMCT, from the moment the FMCT enters into force.

The Focused Safeguards Approach

In sum, due to resource constraints affecting the IAEA and the unlikelihood of getting the NWS to accept extensive safeguards, it appears that the only feasible approach to safeguards implementation under an FMCT is a focused approach. Under this approach, safeguards would apply to: all unirradiated fissile material produced or otherwise acquired after entry into force of the FMCT, for both peaceful and non-proscribed military activities; all facilities that are, have been, or could be capable of producing these materials (primarily enrichment and reprocessing facilities), including decommissioned, shutdown, and future facilities; and other downstream facilities handling fissile material (for storage, processing, utilization, or disposal) produced after entry into force up to the termination point of safeguards.

Over time, focused safeguards might even become the appropriate model for general application. In other words, it is possible to foresee convergence between the current safeguards regime and the measures that are likely to be introduced for the FMCT. Whether this occurs will depend partly on the success of the IAEA's Strengthened Safeguards System (SSS). The SSS resulted from the "93+2" program, which, in the aftermath of revelations about Iraq and North Korea, sought to improve the IAEA's ability to detect clandestine nuclear activities. If the SSS can provide sufficient assurance of the absence of undeclared enrichment and reprocessing facilities, it will make possible a significant reduction in comprehensive safeguards measures in non-nuclear weapon states on those nuclear materials requiring enrichment or reprocessing before they could be considered weapons-usable, e.g., natural uranium, LEU, and plutonium in spent fuel. "Classical" safeguards measures would then be necessary only on material that could be broadly deemed "weapons-usable," i.e., HEU and unirradiated plutonium. Thus, verification under the NPT might evolve to become more focused.

However, this situation does not yet exist, as the success of the SSS is yet to be established. Thus, for the immediate future, it will be necessary to maintain at least some elements of classical safeguards at all facility types in the NNWS. And, for all states, assurance of the absence of undeclared facilities of particular types, such as enrichment and reprocessing facilities, will be as important under an FMCT as it is under NPT safeguards. While a nuclear weapon or threshold state, having opted to join the FMCT, might have limited incentive to pro-

duce undeclared fissile material, this possibility cannot be excluded altogether, and it will be important for the FMCT to provide assurance in this regard. Accordingly, we recommend that safeguards measures under the FMCT be complemented by appropriate measures along the lines of those provided for in the Model Safeguards Protocol, approved in May 1997 by the IAEA Board of Governors as INFCIRC/540. The Protocol provides the legal basis necessary to enhance the IAEA's ability to detect undeclared nuclear material and activities. By concluding this additional protocol, each state undertakes to provide more information about its nuclear program, and the IAEA is given increased rights of access.

FMCT VERIFICATION ISSUES TO BE RESOLVED

Having described our focused approach in general terms, we now identify several more specific details that will have to be worked out in the negotiations. We begin with practical details of how the verification system would itself operate, then turn to some broader technical issues that will affect treaty implementation. Although we do not have recommendations on all of these technical issues, we raise them because we anticipate that they will be potential stumbling blocks when the negotiations get serious. We hope, by providing a list and some discussion of the more difficult technical issues still on the agenda, to help the negotiating parties and interested observers anticipate and prepare for possible problem topics.

To begin with the FMCT verification system itself, we propose that it comprise three basic elements: routine inspections, complementary access, and transparency measures. These would be bolstered by non-routine or "special inspections" along lines already provided for by existing safeguards agreements, but perhaps elaborated in the FMCT as outlined below.

Routine Inspections

There are different opinions about how closely routine inspections under an FMCT should follow the INFCIRC/153 model (including the Model Protocol). The logic behind our approach suggests that, given the different technical conditions and objectives, a safeguards system under an FMCT need not replicate NPT safeguards. However, this raises a possible concern. If an FMCT has less demanding verification requirements than the current NPT, it might undermine the existing safeguards system by establishing two parallel standards for safeguards applications and ultimately lead to convergence on the less demanding standard.

We therefore recommend that, to the extent possible, the IAEA use its standard procedures, measures, and criteria for safeguards on nuclear material and facilities. For those NNWS that have comprehensive safeguards agreements based on the current INFCIRC/153 model, we propose that implementation of those agreements would satisfy the FMCT verification requirements with respect to routine safeguards and nothing additional would be required of them. The NWS and threshold states would require new or amended agreements with the IAEA, however, and key elements for such agreements would presumably be discussed in parallel with treaty negotiations. These should to the extent possible be modeled on existing IAEA safeguards in the NNWS, but we recognize that some modifications may be necessary to take into account additional security constraints (e.g., due to the lack of clear separation between military and civil activities in some of the NWS) and possible facility-specific constraints (e.g., older military reprocessing and enrichment plants might require new safeguards approaches).

Non-Routine Inspections

In informal discussions, there have been suggestions that the FMCT should provide a "challenge inspection" mechanism. Based on the model of the Chemical Weapons Convention, challenge inspections would be those undertaken at the request of another state. However, existing INFCIRC/153-type and INFCIRC/66-type[15] agreements already provide for "special inspections" that can meet the need for challenge inspections. The IAEA can initiate special inspections when it believes that information made available by a state is not adequate for the IAEA to fulfil its responsibilities under the safeguards agreement with that state. A special inspection can be based on the analysis of any information available to the IAEA, including information provided by another state that is concerned about the existence of possible undeclared activities in the state in question. There may be a need, however, to elaborate the "special inspection" mechanism in the FMCT, e.g., by including managed access provisions, and to make it clear that a state can request that the IAEA undertake such an inspection.

Complementary Access

FMCT verification will certainly include technical measures for detection of undeclared production of fissile material after entry into force at declared or undeclared facilities. As part of these measures, the FMCT should provide for managed access[16] for inspections and for the IAEA's right to initiate complementary access along the lines developed for the Model Safeguards Protocol. Under the Protocol, IAEA inspectors have rights of complementary access to any location on a nuclear site and to various locations included in a state's Expanded Declaration (which lists certain additional nuclear activities not covered in original safeguards agreements), and to other locations to carry out environmental sampling. We believe that comprehensive INFCIRC/153 safeguards agreements incorporating Model Protocol measures would satisfy the FMCT verification requirements with respect to complementary access.

The objective of FMCT complementary access would be to detect undeclared enrichment or reprocessing (not undeclared nuclear facilities per se), and to follow up on discrepancies uncovered during the course of routine inspections. An FMCT is unlikely to require detection of any other undeclared nuclear facilities (e.g., reactors, conversion plants, and fuel fabrication plants), since those facilities would not be evidence of undeclared production of fissile material. However, it will be important to have a capability for detection of clandestine plutonium production reactors, because these may indicate the existence of undeclared reprocessing facilities.

Transparency Measures

The verification regime for the FMCT will need to include declarations for all reprocessing and enrichment facilities, regardless of their operational status (including all operational, closed-down, and decommissioned facilities), and for all facilities that store, process, or use fissile material subject to the treaty (such as conversion, fuel fabrication, and storage facilities) during the time that subject material is present. An issue that will need to be resolved is whether there may be a need to declare all facilities and locations with pre-existing stocks to avoid the possible conclusion that these represent new production. Also, there may be a need to declare all facilities that might handle pre-existing fissile material. We believe that no detailed information should be required on military facilities involved in activities that are not proscribed by the FMCT. However, these facilities and locations should at least be listed in states' Expanded Declarations, with a short description of their mission and an indication of whether or note they contain fissile material (though not detailed inventories).

Borrowing Material from Existing Stocks

The inspections and transparency measures described so far deal mainly with verifying nonproduction. However, FMCT verification will need to address another contingency. A state party to the FMCT might have an incentive to clandestinely *borrow* fissile material from pre-existing stocks, or to switch unsafeguarded and safeguarded material. A state might do so to try to falsify the material balance verification at fissile material production plants, or to substitute newly-produced or better-quality material for material less suitable for weapons due to its isotopic composition (e.g., reactor-grade plutonium) or contamination (e.g., plutonium contaminated with americium, or reprocessed HEU contaminated with Uranium-236). Therefore, safeguards measures that address the possibility of borrowing from existing stocks should be developed for fissile material production plants.

Transfers to Other States from Existing Stocks

In addition to the verification system modalities discussed in the preceding sections, several other practical matters will need to be resolved in the treaty negotiations. We raise five such issues here that have the potential to be particularly problematic: material transfers, material storage arrangements, production facilities, downstream facilities, and the naval fuel cycle.

First, the negotiations will have to consider whether material from existing stocks in one nuclear weapon or threshold state, and hence not subject to the FMCT, should be transferable outside the FMCT to another NWS or threshold state. This could occur, for example, because of an interest in the transfer of HEU for naval propulsion. While a desire to maintain supply channels for naval fuel is understandable, transfers like these that take place outside the FMCT could be inimical to the treaty's objectives. After all, states will join the treaty only after assessing their security position relative to others, so transfers that could be misused to alter the nuclear balance might undermine the treaty. We suggest, therefore, that all transfers should be subject to international verification to provide assurance that they are not being made for proscribed purposes.

Stores of Fissile Material

All separated fissile material produced *after* entry into force should be subject to safeguards. To accomplish this objective, two technical difficulties will need to be addressed. First, the safeguards system will need a way to distinguish between newly separated material and any unsafeguarded material sharing the same stores. Similarly, it will also need a way to distinguish between the new product at reprocessing and uranium enrichment facilities and material produced and stored at those facilities prior to entry into force.

Production Facilities

We predict that production of HEU for non-explosive purposes will not be proscribed by an FMCT, but safeguards will still have to be applied to all uranium enrichment activities, regardless of their objective, to ensure that there is no undeclared production of HEU after entry into force. All of the following facilities should be subject to safeguards: large-scale military, dual-use (military/civil), commercial, pilot, and research and development facilities.

Similarly, separation of plutonium, HEU, or Uranium-233 from irradiated material for non-explosive purposes will probably not be proscribed by the FMCT. If so, safeguards will have to be applied to all chemical reprocessing activities to ensure there is no undeclared separation of fissile material after entry into force. All of the following facilities should be subject to safeguards: large-scale military, dual-use, commercial, pilot, and test plants, and all hot cells above a certain size yet to be defined.

For military facilities that may use grandfathered HEU or plutonium but do not enrich or reprocess, measures will need to be developed to provide assurance that there is no undeclared enrichment or reprocessing taking place and/or that no such capability exists in those facilities. Since there will be a need to protect national security information, appropriate managed access provisions will have to be developed.

Downstream Facilities

As mentioned above, FMCT safeguards will have to be applied to all downstream facilities handling fissile material produced after entry into force up to the point of termination of safeguards. The facilities that will have to be placed under safeguards, if they use fissile material produced after entry into force, will be those engaged in the following functions: plutonium, HEU, and Uranium-233 fuel fabrication for test and research reactors and critical assemblies; mixed-oxide (MOX)[17] and HEU fuel fabrication for liquid metal fast breeder reactors; and MOX fuel fabrication for light water power reactors. Fresh fuel stores at any of these facilities will also have to be subject to verification. Likewise, in tritium production reactors using newly produced HEU (i.e., enriched to HEU after entry into force), the fresh fuel should be subject to verification to ensure that it is not diverted for use in nuclear weapons.

A need may arise for some states to convert newly separated fissile material into other chemical or physical forms, e.g., for safety or security reasons. As the material would remain separated and unirradiated, all plutonium and HEU conversion facilities that are intended to handle fissile material produced *after* entry into force should be subject to safeguards. These should include material balance verification on the fissile material (subject to managed access requirements).

In addition to safeguards covering production and use of HEU, separated plutonium, and Uranium-233 after entry into force, it is equally important to implement verification activities for all processes and facilities that will be dealing with excess military and civil fissile material. The negotiating states and the IAEA are likely to wish to preserve as accurate a knowledge of past and present inventories as possible. It will be important to keep track of the material being retired from military stocks so as not to increase the existing uncertainties about historical production and existing stocks. Hence, the following activities should be made subject to immediate verification: the use of released weapons plutonium for fuel fabrication; all other activities related to the disposal of plutonium (e.g., disposal in deep boreholes, or plutonium immobilization with high level waste); and conversion of metal HEU to oxide, followed by its fluorination and blending. Existing bilateral arrangements between the United States and Russia, or any multilateral arrangements with other states that might become involved (e.g., France, Germany, Japan), would be sufficient verification at this time. In due course, all records related to these activities could be transferred to the IAEA to commence international verification.

Naval Fuel Cycle

If HEU produced after entry into force is used in na-

val propulsion, its production should be safeguarded at the enrichment plant and safeguards maintained until it enters naval fuel fabrication facilities. Because of the sensitivity of naval fuel design, neither naval fuel fabrication nor the fuel itself can be safeguarded using conventional nuclear materials accountancy, as that would imply, for example, provision by the operator to the IAEA of information on the amount and isotopic content of the material—considered by all NWS as highly classified information. Thus, a considerable amount of work is needed to devise and implement verification using alternative principles, perhaps drawing on ideas which have been put forward for the verification of nuclear disarmament. Verification of nuclear fuel should not cease until the fuel is in a closed pressure vessel on board ship. Any eventual reprocessing of naval fuel would also necessarily be subject to verification at the reprocessing plant.

CONCLUSIONS

A fissile material cut-off treaty will affect individual states differently due to variance in their attitudes about the role of fissile material in national security, in their nuclear fuel cycles, and in their fissile material inventories. The problem is how to negotiate a treaty that is favorable to all participants, given that interests and priorities vary so much. We have concluded that it is politically and financially nonviable, at this stage in the nuclear disarmament process, to attempt to apply a full-scope safeguards regime, similar to that required of non-nuclear weapon state parties to the NPT, to verify compliance with an FMCT by the NWS and threshold states. Fortunately, that is also not required, as the verification needs of an FMCT will be more limited than those of the NPT. Focused verification can meet the needs of the FMCT in a cost-effective manner. Such verification would be confined to safeguarding enrichment and reprocessing facilities in the nuclear weapon and threshold states, coupled with verification of HEU and separated plutonium produced after entry into force of an FMCT, and supported by measures to detect possible undeclared enrichment and reprocessing activities. Even if this approach is accepted in general, however, several difficult technical issues will remain. We have identified these here in an attempt to let people know what issues are likely to arise once FMCT negotiations commence.

[1] Commonwealth of Australia, Department of Foreign Affairs and Trade, *Report of the Canberra Commission on the Elimination of Nuclear Weapons* (Canberra: National Capital Printers, 1996).

[2] H.E. Mr. John B. Campbell, "Fissile Material Cut-Off Treaty: Australian Views," statement delivered by the 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, Geneva, April 30, 1998.

[3] The "threshold states" are India, Israel, and Pakistan. Although it is debatable whether this term is still appropriate for India and Pakistan, it is used here for convenience.

[4] For the latest discussions of FMCT issues, see the proceedings of the "Seminar Conference on the Technical Issues of a FMCT," Geneva, May 11-12, 1998, and papers presented at the Fissile Material Cut-Off Treaty seminar, organized by Sweden's Defence Research Establishment (FOA), Hasseludden, Sweden, June 3-5, 1998.

[5] *General Assembly Resolution: Prohibition of the Production of Fissile Material for Nuclear Weapons and Other Nuclear Explosive Devices*, U.N. General Assembly document RES/48/75L, December 16, 1993.

[6] 1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Final Document: Part I: Organization and Work of the Conference*, New York, 1995, Document No. NPT/CONF.1995/32/Decision 2, "Principles and Objectives for Nuclear Non-Proliferation and Disarmament. "

[7] Katherine L. Starr, "The Why and Whither of Fissile Material Cutoff," Report of a Conference at Schlagenbad, Germany, July 25-27, 1997.

[8] See, for example, George A. MacLean, "Taking Stocks: Fissile Materials Stockpiles and Proposed Cutoff Treaty," in *Non-Proliferation Agreements, Arrangements and Responses: Proceedings of the 1996 Canadian Non-Proliferation Workshop* (Toronto: Centre for International and Security Studies, 1997).

[9] *IAEA Information Circular: Communications Received from Certain Member States Concerning Their Policies Regarding the Management of Plutonium*, IAEA document INFCIRC/549, Vienna, March 16, 1998.

[10] The *IAEA Safeguards Glossary* (Vienna: International Atomic Energy Agency, 1987) defines direct-use material as nuclear material that can be converted into nuclear explosive components without transmutation or further enrichment, i.e., plutonium containing less than 80 percent Plutonium-238, HEU, and Uranium-233.

[11] 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," paper presented at the Workshop on a Cut-Off Treaty, Toronto, Canada, January 17-18, 1995.

[12] Significant quantity is defined by the IAEA as the approximate quantity of nuclear material with respect to which, taking into account any conversion process involved, the possibility of manufacturing a nuclear explosive device cannot be excluded. Timeliness is a component of IAEA inspection goals that establishes the maximum time that may elapse between diversion and its detection by IAEA safeguards.

[13] Thomas B. Cochran and Christopher E. Paine, *The Amount of Plutonium and Highly-Enriched Uranium Needed for Pure Fission Nuclear Weapons* (Washington, D.C.: Natural Resources Defense Council, Revised April 13, 1995).

[14] Bruno Pellaud, "International Verification of U.S. and Russian Materials Released for Storage and Disposition,"paper presented at the International Policy Forum: Management & Disposition of Nuclear Weapons Materials, Landsdowne, Virginia, February 12, 1997.

[15] INFCIRC/66-type agreements are facility-specific safeguards agreements, that apply in the NWS and the threshold states.
[16] Managed access under the Model Protocol means special arrangements in order to prevent the dissemination of proliferation-sensitive information, to meet safety or physical protection requirements, or to protect proprietary or commercially-sensitive information. Such arrangements, however, shall not preclude the IAEA from conducting activities necessary to provide credible assurance of the absence of undeclared nuclear material and activities at the location in question.
[17] Mixed-oxide is a blend of plutonium and uranium used to fuel thermal and fast neutron reactors.