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FM(C)T Meeting Series

FM(C)T: Elements of the Emerging Consensus

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Background document prepared for the meeting “Fissile Material (Cut-off) Treaty: Elements of the Emerging Consensus” 23 March 2016

Pavel Podvig

Introduction

A treaty that would ban production of fissile materials for nuclear weapons has been on the agenda of the international community for more than 20 years. In 1995, a report to the Conference on Disarmament, prepared by Ambassador Shannon, included an agreed mandate for future negotiations. The report emphasized that the agreement on the mandate included an understanding that the negotiations could consider any relevant issue related to the scope of the treaty.[1] The Shannon report and the mandate it contained became an important starting point for efforts to achieve a ban on the production of fissile materials for weapons.

Discussions on the parameters of the future treaty and its importance for nuclear disarmament and non-proliferation have continued over the years, even as the negotiations in the Conference on Disarmament have failed to commence. The treaty still has the strong support of the international community and is widely considered a vital element of the future international security architecture.

In the past few years, efforts to begin the negotiations have intensified. In 2013, the United Nations General Assembly adopted a resolution that established a Group of Governmental Experts (GGE), which was requested to make recommendations on the future treaty.[2] The GGE, which held its working sessions in 2014–2015, became the

1 *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.

2 *Treaty Banning the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices*, A/RES/67/53, 4 January 2013.

first multinational forum to discuss the treaty at the level of governmental experts. In May 2015, the GGE issued a report that summarized the results of the discussions and contained recommendations for future work.[3]

In another important development, shortly after the conclusion of the work of the GGE, the Government of France submitted to the Conference on Disarmament its draft of the treaty.[4] It became the first State-sponsored draft of an internationally verifiable treaty that was consistent with the mandate contained in the Shannon report.[5] Another draft of the treaty based on the Shannon report, prepared by the International Panel on Fissile Materials, was introduced in the Conference on Disarmament in 2009.[6] Members of the Conference on Disarmament also sponsored several meetings on various aspects of the treaty.[7] In preparation for the work of the GGE, a number of States submitted their views on the key elements of the treaty.[8] There is also a large amount of academic work devoted to technical and political issues associated with the ban on fissile material production.[9]

Discussions concerning the treaty, including those in the GGE, have demonstrated that there are significant differences regarding its objectives, scope and the role that the treaty should play in efforts to strengthen international security. At the same time, the discussions have reached a broad agreement on a number of the elements of the future treaty. Although the participants still hold different views on some of the key issues, such as the definition of fissile material or the scope of the treaty, there appears to be a

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3 *Report of the Group of Governmental Experts to Make Recommendations on Possible Aspects That Could Contribute to but Not Negotiate a Treaty Banning the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices*, A/70/81, 7 May 2015.

4 "Projet français de Traité interdisant la production de matières fissiles pour les armes nucléaires ou d'autres dispositifs explosifs nucléaires (FMCT)", 9 April 2015, http://www.delegfrance-cd-geneve.org/IMG/pdf/2015-04-09_projet_traite_fmct_version_finale_fra.pdf; "Draft Treaty Banning the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices Submitted by France", 9 April 2015, http://www.delegfrance-cd-geneve.org/IMG/pdf/2015-04-09_projet_traite_fmct_version_finale_eng.pdf.

5 In 2006, the United States submitted a proposal for a different negotiating mandate and a draft treaty that did not contain provisions for international verification. Stephen G. Rademaker, "Rising to the Challenge of Effective Multilateralism", US Department of State, 18 May 2006, http://2001-2009.state.gov/t/isn/rls/rm/66419.htm; US Department of State, "Texts of the Draft Mandate for Negotiations and the Draft Treaty", 18 May 2006, http://2001-2009.state.gov/t/isn/rls/other/66902.htm.

6 *Draft for Discussion Prepared by the International Panel on Fissile Materials*, CD/1878, 15 December 2009, http://fissilematerials.org/library/G1060052.pdf; International Panel on Fissile Materials, *Global Fissile Material Report 2008: Scope and Verification of a Fissile Material (Cutoff) Treaty*, October 2008, http://ipfmlibrary.org/gfmr08.pdf.

7 See, for example, Conference on Disarmament, "Australia–Japan Experts Side Event on FMCT Definitions, Palais des Nations, Geneva, 14–16 February 2011. Report of the Chair, Ambassador Peter Woolcott of Australia", CD/1906, 14 March 2011.

8 For example, United States, "Fissile Material Cutoff Treaty: Views of the United States of America, pursuant to UNGAR 67/53 (2012)", 2012, http://www.unog.ch/80256EDD006B8954/(httpAssets)/BD142DD9E3BA954BC1257B7C00321B78/$file/USA.pdf.

9 For a recent comprehensive overview, see Annette Schaper, "A Treaty on Fissile Material: Just Cutoff or More?", PRIF, 2011.

convergence of views on the meaning of the treaty obligations, of the general structure of the treaty, and of the basic characteristics of the verification system that the treaty will create.

This paper presents the elements of this emerging consensus in order to stimulate further productive discussion of the treaty. It focuses on the points of agreement to illustrate that a number of important issues have already been effectively resolved. Moreover, this approach helps to emphasize the remaining differences and to make clear the nature of the compromises that would be required to successfully negotiate a viable treaty.

This analysis deals with those elements of the treaty that have a more technical nature—fissile material production, a verification system and the issue of existing stocks. Several important points, such as the structure of the treaty implementing organization, the enforcement mechanism and the question of entry into force, are not considered. It should be noted, however, that there is agreement on many of those issues as well.

Central obligation of the treaty

The central provision of the future treaty is a ban on "production of fissile material for nuclear weapons or other nuclear explosive devices".[10] In practice, however, production of fissile materials involves processes, technologies and facilities that are largely independent from the eventual destination of the material. While it is true that nuclear-weapon States operated dedicated facilities to produce materials for their weapon programmes, this was done primarily to increase efficiency of production rather than to employ processes that would be unique to weapon material production. For those fissile materials that are considered relevant for nuclear weapons, there is no fundamental difference between production of these materials for weapons or for some other purpose. This means that in order to translate the proposed ban on the production of fissile materials for weapons into enforceable and verifiable treaty obligations, the concept of a ban has to be expressed in a more detailed way.

First, there is a general agreement that the treaty would not prohibit all production of fissile materials, since most materials used in weapons have legitimate non-weapon uses (whether civilian or non-explosive military). This means that in order to fulfil its purpose, the treaty should require that all fissile material produced be submitted to verification. The verification system would have to be designed in a way that ensures that any material submitted to it is not used for weapons purposes.

Second, it is agreed that the treaty should prohibit production of fissile material that is not submitted to verification. In practice this would mean that the verification system should include measures to prevent undeclared or clandestine production of fissile material.

10 CD/1299, op. cit.

Finally, any material that is submitted to verification would be covered by treaty obligations up to the point when it is rendered unusable. Indeed, this principle, sometimes referred to as irreversibility, would be the core element of the treaty and create its most meaningful obligation.[11]

There is also general understanding that the treaty should prevent acquisition of fissile material from other sources, such as through transfers from another State or even from non-State groups. In order to do so, the treaty could close down these options by requiring that all acquisitions be treated like newly produced material. This approach, while not prohibiting all transfers, would prevent situations in which a State could circumvent the central obligation of the treaty by acquiring material from a source that is not treaty-accountable. This approach also enjoys broad support and is unlikely to be controversial.[12]

There is considerable support for a provision that would prohibit transfers of fissile materials to other States.[13] This obligation, however, would be redundant in most relevant cases. If the recipient country is a member of the treaty, any transferred material would have to be submitted to verification (as newly acquired material) even if it was not treaty-obligated material in the country of origin. Transfers of treaty-obligated material to a country that is not a treaty party should be prevented by the verification arrangements, which would explicitly prohibit withdrawal of material that had been submitted for verification. The only situation in which a transfer may fall outside the scope of the treaty would be a transfer of non-treaty-obligated material—which would therefore not be covered by verification provisions—to a State that is not a treaty member. While the treaty may still call for a ban on transfers of this kind, it should be understood that this ban would be impossible to detect or verify unless the treaty were to extend its obligations to all categories of fissile materials (including, for example, the material in active nuclear weapons).

This interpretation of the central obligation of the treaty has been supported by most participants in the discussions on the FM(C)T. Corresponding provisions are included in all drafts that assume that the treaty will be internationally verifiable.[14] To summarize, a ban on production of fissile materials for nuclear weapons and other explosive devices is generally understood to mean the following:

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11 A/70/81, para 11, op. cit. An explicit no-withdrawal provision in the treaty would help to distinguish its obligations from those accepted by nuclear-weapon States in their Voluntary Offer Agreements with the International Atomic Energy Agency (IAEA). The latter allow withdrawal of the material that was voluntarily submitted to IAEA safeguards. See International Panel on Fissile Materials, *Global Fissile Material Report 2007: Developing the Technical Basis for Policy Initiatives to Secure and Irreversibly Reduce Stocks of Nuclear Weapons and Fissile Materials*, 2007, Chapter 6, http://ipfmlibrary.org/gfmr07.pdf.

12 *IPFM Report 2008*, Article I.2, op. cit.; A/70/81, para 6, op. cit.

13 A/70/81, para 17, op. cit.

14 Ibid., paras 43, 61; *Draft Treaty Submitted by France*, Articles 5.1(b), 5.1(c), op. cit.; *IPFM Report 2008*, Articles III.3.i(b), III.3.ii, op. cit.

> All fissile material that is produced or acquired from any source should be submitted to verification, which is designed to ensure that this material is not used for nuclear weapons and that no production or acquisition of fissile material outside the established verification system is taking place.

Verification system

The agreed interpretation of the central provision of the future treaty outlined above imposes certain requirements on the architecture of the verification system that would be required to support effective implementation of the treaty. The system would have to include at least three components, each having a distinct verification mission:

- verification at production facilities;
- downstream verification to ensure non-use of declared fissile material for weapons;
- detection of undeclared production facilities.

The first component of the verification system would include a set of measures implemented at production facilities either to ensure that they do not produce fissile materials or, if they do, that all produced material is properly declared and submitted to verification. The second component would follow the submitted fissile material "downstream" to ensure that it is not used in nuclear weapons or withdrawn for other purposes. These measures would include provisions that would allow non-proscribed military use of the material, which is discussed in a separate section.

Finally, the treaty would have to include arrangements to allow detection of covert fissile material production activity. Some of these measures would be an integral part of the routine monitoring activities at declared production facilities. However, it is important to emphasize that there is a widely shared understanding that the treaty should include other mechanisms, such as non-routine or challenge inspections, as well.[15]

Fissile material production and production facilities

Specific arrangements that would have to be implemented at declared production facilities would depend on the agreed understanding of what constitutes production, what kind of facilities should be considered fissile material production facilities and which of them would have to be declared and submitted to routine verification.

Most existing treaty drafts include an explicit definition of fissile material production that includes uranium enrichment and chemical reprocessing that separates fissile materials from fission products or from unirradiated fuel.[16] Other processes, such as enrichment of

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15 A/70/81, para 61, op. cit; *Draft Treaty Submitted by France*, Article 5.1(c), op. cit; *IPFM Report 2008*, Article III.3.i.b, op. cit.

16 A/70/81, para 38, op. cit; *Draft Treaty Submitted by France*, Article 2.2, op. cit.

plutonium in the Pu-239 isotope, are sometimes considered as well.[17] These definitions, however, assume an agreement on a specific meaning of the term “fissile material”, in this case unirradiated direct-use material. Other definitions of fissile material would require a different definition of production. For example, if the term fissile material were to include fissile isotopes in irradiated fuel, irradiation in a reactor would be categorized as production.

The treaty, in fact, may not need to identify specific technologies that can be used to produce fissile material. It can define production as any activity that produces new fissile material. Indeed, if understood this way, the definition of production would cover all possible activities and processes that are relevant from the point of view of the central provision of the treaty.

Once fissile material production is defined, a production facility can be defined as a facility that is capable of producing fissile materials. This definition also does not imply any specific production process.

Although the treaty may eventually include a detailed definition of production and production facilities, this would not affect the structure of the treaty and the basic principles of the verification system.

Verification at production facilities

As discussed earlier, one of the central elements of the treaty is the verification system that would ensure that all material produced at production facilities is properly declared and accounted for. To comply with the treaty obligations, States would have to declare their production facilities and submit them to verification. The expert discussions have identified several categories of production facilities that may require a different verification approach.

First, there is a general understanding that small facilities may be exempt from verification.[18] This exemption could apply to laboratory-scale facilities, but it may cover larger facilities as well. The threshold is likely to be rather low, so that it does not create a verification gap in the treaty. It can be set to zero as well.

Further, this understanding assumes that all facilities that are capable of producing fissile materials and have capacity above the agreed threshold should be submitted to verification. This would have to apply to those facilities that are not operating if they maintain the capability to produce fissile material.[19]

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17 *IPFM Report 2008*, Article II.2, op. cit; *US Draft Treaty, 2006*, Article II.2 op. cit.

18 A/70/81, para 41, op. cit.; *Draft Treaty Submitted by France*, Article 2.3, op. cit.

19 In the current IAEA safeguard practice, this would correspond to a facility that has been shut down or closed down, but that has not been decommissioned. International Atomic Energy Agency, *IAEA Safeguards Glossary*, 2002, para 5.29–5.31.

One category of facilities that is often discussed separately includes facilities that were producing fissile material for weapons in the past. Since almost all weapon States have used dedicated facilities for weapon material production, it has been suggested that the treaty should explicitly require that these facilities be disabled, decommissioned and dismantled or converted to civilian uses.[20] This is a reasonable demand that aims to ensure that no State has standby capacity to produce fissile materials for weapons. However, it is not clear if these facilities warrant a separate category. Whether they are decommissioned or converted to civilian uses, they would be covered by the general verification provisions that apply to all production facilities.

One issue that may deserve special consideration is whether States should declare those former production facilities that have been decommissioned or dismantled by the time the treaty enters into force.[21] This question may also be relevant for facilities that were producing fissile materials in the past, but were converted to activities that do not involve fissile material production. The treaty may require these facilities to be declared, although States with substantial past production are likely to object.

Finally, it is generally understood that verification measures applied at production facilities would probably have to be facility-specific, even if the general principles of verification and its objectives were to be applied universally. The level of verification activity would depend on the status of the facility (under construction, operating, shut down, or decommissioned) and on the specific production activity that is carried out at the facility.[22]

Taking into account these considerations, the way in which the issue of production facilities could be handled can be summarized as follows:

At the time of entry into force, each State party declares all its facilities that are capable of producing fissile materials. The declaration may include all facilities, including those with capacity below the agreed threshold. It may also include decommissioned and converted facilities that are no longer capable of producing fissile materials. Following the declaration, the implementing organization will determine the appropriate level of verification activity and specific measures to be applied at each facility on the list. Verification activities at small, converted or decommissioned facilities may be limited to periodic confirmation of their exempt status. Operational facilities or shut-down facilities that preserve the capability to produce fissile materials would be placed under appropriate continuous monitoring.

The verification measures to be implemented at each facility could be modelled after standard IAEA safeguards procedures, although they might be modified to take into account FM(C)T verification objectives, as well as the fact that the design of some of the older production facilities may complicate verification.[23] There is an agreement that

20 *Draft Treaty Submitted by France*, Article 3.2, op. cit.; *IPFM Report 2008*, Articles I.4, III.3.i, op. cit.

21 *Draft Treaty Submitted by France*, Article 5.4, op. cit.

22 A/70/81, para 52, op. cit.

23 *IPFM Report 2008*, Chapters 4–5, op. cit.

States will have the right to implement “managed access” to their facilities in order to protect sensitive information.[24]

Downstream verification

The next key element of the FM(C)T required to enable the treaty to achieve its goal is the set of measures that would ensure that no fissile material that is submitted to verification can be used in nuclear weapons.[25] This verification system would have to follow the material from the point of origin throughout its entire life cycle. These arrangements are often referred to as “downstream verification”.

There is a firm understanding that any new material that is produced after entry into force would have to be submitted to downstream verification and that once submitted, the material could not be withdrawn. As discussed earlier, this is an integral part of the central obligation of the treaty. This understanding can be easily extended to any other acquisitions of fissile material, for example, through a transfer from another country or from a non-State entity. The downstream verification system would also be capable of handling material that originates from a pre-existing stock, whether civilian or military.

As for termination of verification, the agreement is that the verification measures could be lifted only when the material is no longer considered fissile material as defined in the treaty. This may be a result of consumption, irradiation or dilution of the material. The approach to termination of safeguards adopted by the IAEA can provide a useful model.[26] It is also reasonable to include a provision that would require any material that is transferred to another State to remain under verification.

Downstream verification of the material that is produced for civilian use should not present any challenges, as it can draw on the extensive experience of the IAEA safeguards and can employ similar practices and tools.[27] The FM(C)T verification system, however, would have to include a component that deals with fissile material produced for non-civilian uses. This would require a separate arrangement.

Since the FM(C)T objective is defined as a ban on production of fissile material for use in nuclear weapons and other explosive devices, it is usually understood that States would be allowed to produce fissile material for non-proscribed military purposes.[28] This may include, for example, production of highly enriched uranium (HEU) for naval reactors as well as for fuel used in military research or isotope production reactors. The procedures that would normally be used to verify non-weapon use of fissile material submitted to

24 A/70/81, para 53, op. cit.; *Draft Treaty Submitted by France*, Articles 5.8–5.10, op. cit.; *IPFM Report 2008*, Chapter 8, op. cit.

25 A/70/81, para 43, op. cit.; *Draft Treaty Submitted by France*, Article 5.1(b), op. cit.; *IPFM Report 2008*, Article III.3.ii, op. cit.

26 *IAEA Safeguards Glossary*, 2.12, op. cit.

27 A/70/81, para 59, op. cit.; *IPFM Report 2008*, Article III.2, op. cit.

28 A/70/81, paras 21, 54, op. cit.; *Draft Treaty Submitted by France*, Article 6.2, op. cit.; *IPFM Report 2008*, Articles III.2, III.3, op. cit.

verification may not be applicable in this case, since the military applications are likely to require a certain degree of secrecy. In IAEA practice, the material that is intended for military non-explosive use may be withdrawn from safeguards.[29] Specific arrangements that would be implemented in this case have not been developed yet, since no State has exercised its right to withdraw material from IAEA safeguards in this way.

There are a number of ways the FM(C)T could implement provisions on handling material intended for use in non-proscribed military purposes. This could be done by having a separate protocol that would specify the verification arrangements in such cases. These arrangements could be applied universally to all States or could be negotiated on a State-by-State basis to account for different practices in using fissile materials in military applications. It is, however, agreed that the general principles of verification in this case should be the same as in the civilian domain in that they should exclude the possibility of diversion of the material to weapons.

Undeclared production

The final key component of the verification system is a set of arrangements designed to detect undeclared production activities and facilities. Verification measures described in the preceding sections would apply only to declared production facilities and declared material. This leaves two main possibilities for producing unaccounted material that could then be made available for weapon purposes. One is *undeclared production at declared facilities* and the other is *production at undeclared facilities*.[30] A robust verification system should be able to close both these acquisition paths.[31]

The first option, undeclared production at a declared facility, can and should be addressed by the verification procedures that are implemented at that facility. The second would most likely require special arrangements that would include non-routine or challenge inspections, requests for complementary access and other similar measures.[32] Detection of signs of undeclared activity can be entrusted to the FM(C)T implementing organization, which would be able to rely on its own information as well as on information supplied by member States.[33] Some proposals suggest that the arrangements for detection of undeclared facilities could be modelled after the provisions of the Additional Protocol (INFCIRC/540), which includes such measures as wide-area environmental sampling and disclosure of detailed information about all stages of the nuclear fuel cycle.[34] It is likely,

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29 *IAEA Safeguards Glossary*, 2.14, op. cit.

30 Another possibility is undeclared acquisition of material from a foreign party, for example, from a State that is not party to the FM(C)T or the Non-proliferation Treaty, which would be a prohibited transfer.

31 A/70/81, para 49, op. cit.; *Draft Treaty Submitted by France*, Article 5.1(c), op. cit.; *IPFM Report 2008*, Article III.3.i.b, op. cit.

32 A/70/81, para 61, op. cit.

33 *Draft Treaty Submitted by France*, Article 8.1, op. cit.; *US Draft Treaty*, Article III.2, op. cit.

34 International Atomic Energy Agency, *Model Protocol Additional to the Agreement (s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards*, INFCIRC/540 (Corrected), May 1997.

however, that a number of States will object to some of the most intrusive detection measures and may insist on less stringent provisions.

To summarize, there appears to be a strong agreement that the treaty will have to include provisions designed to detect undeclared production facilities, even though there are still significant differences over the specifics of these arrangements.

Existing stocks

The question of whether the FM(C)T should address the fissile materials that were produced before entry into force is one of the most divisive issues in the discussions on the future treaty. It is nevertheless possible to outline an agreed approach that the treaty could adopt in dealing with existing stocks of fissile materials.

Most importantly, even if the treaty imposes no obligations on its parties regarding existing stocks, nothing in the treaty would prevent a State from submitting any amount of its fissile material produced before entry into force to verification under the treaty. This material can be treated as new production or acquisition and the verification arrangements would ensure that it is not used for proscribed purposes. If the material submitted to verification is of military origin, the State may want to protect sensitive information associated with it (such as isotopic content). This can be dealt with in a variety of ways, such as mixing it with non-military material to mask the sensitive information. If the material is submitted to verification on a voluntary basis, there would be no restriction on such manipulations.

The procedure would be significantly more complex if the treaty were to include an obligation to submit to verification a certain category or a specified amount of material from existing stocks. For example, the FM(C)T may include provisions that extend its coverage to all existing stocks of civilian material or to a specific amount of fissile material declared excess to military purposes. In this case, the procedure should include measures that would verify that all this material has indeed been submitted to verification.

These measures could be relatively easily implemented in those cases where the material in question is already under verification. This is the case for all fissile materials in Non-Proliferation Treaty (NPT) non-nuclear-weapon States and also for the material in weapon states that has been placed under IAEA or similar safeguards.[35] The material covered by

35 This would include some HEU and civilian plutonium in France and the United Kingdom that has been placed under Euratom safeguards as well as about 2 tons of US plutonium that is under IAEA safeguards. *Global Fissile Material Report 2007*, pp. 72–73. India, Israel, and Pakistan have some nuclear material under INFCIRC/66-type safeguards.

bilateral verification arrangements could also be in this category.[36] Indeed, it has been suggested that this material should be considered treaty-obligated in the future treaty.[37]

The experience of the US–Russian bilateral process also demonstrates the possibility for more complex arrangements to allow elimination of a specified amount of material and confirm the weapon-origin of the material. Under the Plutonium Management and Disposition Agreement, the United States and the Russian Federation agreed to eliminate 34 tons of weapon-grade plutonium. The quantity of plutonium will be verified during the disposition process. Also, in a joint project, known as the Trilateral Initiative, the United States, the Russian Federation and the IAEA demonstrated the possibility of placing sensitive weapon-origin fissile material under IAEA safeguards. The results of this work strongly suggest that if necessary, the FM(C)T obligations could be extended to a wide range of categories of fissile materials produced before its entry into force.

It is important to emphasize that even though the treaty may not include any provisions related to pre-existing stocks, it will inevitably create a legal, technical and organizational structure that would be capable of accepting existing fissile materials. The downstream verification system that the treaty will establish to deal with new production will be capable of accepting past production as well. It will ensure that once the material is submitted to verification, it can no longer be used for weapons.

Conclusion

The points of agreement described above could provide a useful basis for further discussion of the treaty. They show that the discussions so far have already made significant progress. However, the remaining differences should not be underestimated. Indeed, the emerging consensus covers only the general structure of the treaty and some of its key elements. Depending on the choices made during negotiations, these elements could take many different forms. For example, the specifics of the verification system design will depend on the choice of the definition of fissile material that the treaty adopts. A downstream verification system that follows HEU only would be quite different from the one that follows all enriched uranium. Other aspects of the treaty, such as its verification objectives, should be taken into account as well.

It is also clear that more technical work will have to be done to further expand the range of options available to negotiators. It has already been demonstrated that the existing technologies can provide a solid foundation for an effectively verifiable treaty. Further work in this area would help in exploring additional ways to strengthen the treaty. The outline of the points of agreement may help provide direction to these efforts.

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36 This includes weapon-grade plutonium in Russia that is subject to monitoring by the United States. See “Agreement Between the Government of the United States of America and the Government of the Russian Federation Concerning Cooperation Regarding Plutonium Production Reactors”, 23 September 1997, http://ipfmlibrary.org/gov97.pdf.

37 *IPFM Report 2008*, Article I.5.i, op. cit.

Finally, a closer look at the emerging consensus could help States to obtain a better understanding of disagreements and to examine compromises that would move the negotiations forward. The progress that has been made so far creates good conditions to do so.

Fissile Material (Cut-off) Treaty: Remaining Challenges

Annette Schaper

After decades of stagnation at the Conference on Disarmament, some progress towards the proposed Fissile Material (Cut-off) Treaty (FM(C)T) was achieved in 2014 and 2015: the United Nations General Assembly established a Group of Governmental Experts (GGE) whose task was to "make recommendations on possible aspects that could contribute to but not negotiate a treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices".[1] The GGE convened during 2014 and 2015 and issued a report in May 2015.[2]

The GGE document reveals both emerging areas of consensus and disagreements. There seems to be a consensus on the general structure of the treaty: there should be central obligations, verification, and definitions.[3] This is progress in comparison with the past, when, for some years, key delegations rejected any verification.[4] But, not surprisingly, these areas of consensus do not go into detail, and the GGE members agree to disagree on what precisely the central obligations, verification, and definitions should look like. In 2012, upon request of the United Nations General Assembly, 36 delegations submitted statements on their views on an FM(C)T. A close look at these statements reveals that there is a broad spectrum of views and many contradictions as to what the various

1 General Assembly, *Treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices*, UN document A/RES/67/53, 4 January 2013.

2 General Assembly, *Group of Governmental Experts to make recommendations on possible aspects that could contribute to but not negotiate a treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices*, UN document A/70/81, 7 May 2015.

3 See Pavel Podvig, "Fissile Material (Cut-off) Treaty: Elements of the Emerging Consensus", *UNIDIR Resources*, 2016.

4 "Texts of the Draft Mandate for Negotiations and the Draft Treaty" (U.S. Department of State, May 18, 2006), http://2001-2009.state.gov/t/isn/rls/other/66902.htm.

aspects of the treaty should be.[5] The GGE has created an overview of the many variations of the possible positions, but has not resolved the disagreements and has not attempted to do so. At the start of negotiations, such disagreements are typical, and the overview is more than was available before, when it was not clear at all what the treaty could look like, when only fragments of positions were visible.

The stage is set: many discussions have taken place, the overall structure of the treaty seems to be outlined, many starting positions are known, as are disagreements between delegations, and a large majority of delegations wants a treaty. Thus, negotiations could and should start—although they are seemingly not imminent, just as before the GGE sessions. It is written in the stars whether historical circumstances will allow the beginning of negotiations next year or whether we will wait another 20 years.

Many analysts explore reasons for the deadlock or make suggestions as how to overcome it. This paper instead discusses what could be done in the meantime, as long as the deadlock lasts. It would be redundant to repeat the GGE endeavour, as there is hardly anything on the diplomatic level that has not yet been discussed. However, there is something that could be done, which would be neither negotiation nor repetition, and which nevertheless would provide progress: that would be to undertake further investigation or research into the many technical aspects and questions that are unclear to the diplomats and observers, and many of which are unclear even to technical experts. Were the negotiations to start now, diplomats would need to understand some specific background. Consequently, they would invite experts for clarification. But not all technical questions have answers that are sufficiently clear to provide the background for negotiations. Such technical challenges were not addressed in the GGE report. The time until negotiations start could be used to allow scientific experts to work on such questions and trigger scientific research projects.

One historic example of such an approach is the Group of Scientific Experts (GSE) from various countries, which investigated monitoring technologies and data analysis over three decades, until historical circumstances offered the opportunity to negotiate a treaty.[6] Thanks to the results of the GSE's work, a consensus on the verification regime was found relatively quickly, as it was possible to lay all options on the table from which the delegations could choose. All options were well understood. As an example, at the beginning of the GSE's work it was not clear whether an underground nuclear explosion could be distinguished from an earthquake by analysing seismic waves, but scientific progress in seismology, triggered by the GSE, provided clarity. The GSE found adequate and convincing methods that now are part of the verification methods of the Comprehensive Nuclear-Test-Ban Treaty Organization.

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5 The views of Member States are available at: http://www.unog.ch/unog/website/disarmament.nsf/%28httpPages%29/384E4AAF5A1D7189C1257B7C003140CA?OpenDocument&unid=B8A3B48A3FB7185EC1257B280045DBE3.

6 "History: summary", Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, 30 June 2016, https://www.ctbto.org/the-treaty/history-summary/.

Similarly, there are several technical questions related to FM(C)T verification to which the answers are unclear. Thus, today, it would still be difficult to provide a list of options to choose from.

In the following, six examples of such unclear technical problems will be presented.[7] It is recommended that they be further investigated in order to facilitate future FM(C)T negotiations:

- Detection of undeclared production;
- Facilities containing secrets;
- Facilities not designed for safeguards;
- Verifying naval fuel production;
- Verification problems because of black boxes of unverified materials;
- Military production of tritium.

Detection of undeclared production

Independently of the agreed scope, verification arrangements and specific definitions of terms, it is clear that it would not be sufficient to cover only declared facilities, materials, and activities. Such a restriction would not provide assurance that all parties were complying with the terms of the treaty. Additionally, there must be a certain probability that illegal undeclared activities will be detected. There are various measures that could or could not be used for this purpose, such as the use of other information, wide area monitoring, environmental sampling, or special inspections and access rights during inspections. It is the task of the delegates to negotiate and find a consensus on which of many variations of measures will be chosen. A set of possible measures that would be available today was discussed during the negotiations of the Additional Protocol (AP). While it is clear that the AP could not simply be copied for use in the FM(C)T negotiations, some of its elements might be more or less appropriate, although they may require further research, as it is unclear whether they are sufficiently precise.

The weakest point is the early detection of clandestine production of highly enriched uranium (HEU) because enrichment emits fewer effluents than plutonium. Detection is easier in cases of States without existing civilian enrichment facilities than in those that already run such facilities. In the latter, environmental traces of enrichment processes are present anyway and therefore cannot be used as an indicator. In this case, other State parties are likely to apply national technical means to determine the initial locations where inspections should be conducted. An additional method could be detection of the feed material for centrifuge plants, e.g. uranium fluoride (UF6).[8] In any event, a clandestine plant is likely to release traces that could be analysed. Furthermore, such a plant would run the risk of being detected by societal verification. As soon as a suspicion

7 Annette Schaper, *A Treaty on Fissile Material: Just Cutoff or More?*, PRIF Report no. 109, Peace Research Institute Frankfurt (PRIF), 2011.

8 R. Scott Kemp, "Initial Analysis of the Detectability of UO2F2 Aerosols Produced by UF6 Released from Uranium Conversion Plants", *Science & Global Security*, vol. 13:3, 2008 p. 115.

is aroused, on-site inspections are an appropriate tool to create clarity. Further research should investigate the possible precision of detection measures.

Clandestine reprocessing for plutonium production is much easier to detect than enrichment. Reprocessing emits characteristic effluents, including noble gases such as krypton-85 that are extremely difficult to contain and that can be detected even in small traces at distances of several kilometres. This method is useful as long as a country does not legally reprocess for declared purposes. There are certain technical activities in nuclear weapon States that involve handling of plutonium but which cannot be inspected, such as refabrication, maintenance, or dismantlement of warheads. Fortunately, the environmental signatures released by these activities differ greatly from those released by reprocessing.

For diplomats in future negotiations, an overview of detection methods would be useful. The overview should contain information on the capabilities and limitations, intrusiveness, costs, open research questions and ongoing projects, fields where the methods are applied, such as in the Additional Protocol, and alternatives to the methods, if they exist.

Facilities containing secrets

A difficult problem arises from the fact that the FM(C)T deals with “sensitive” information, e.g. information that is related to nuclear weapons. This is different from the verification of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), because in non-nuclear weapon States there is no such information. This sensitive information may concern certain facilities, especially production facilities formerly used for nuclear weapon purposes. In discussions, the problem of “difficult” facilities is frequently raised by delegates from several nuclear weapon States, claiming that there are facilities at which verification is not applicable. A distinction must be made between two aspects of this issue: firstly, the facilities may contain secrets, as explained above; secondly, there might be technical difficulties in relation to verification, which will be discussed in the next section on facilities not designed for safeguards.

The secrets that the owners of such facilities want to protect vary: they may relate to isotopics of fissile material that is being used in nuclear weapons, or to tools or equipment remaining in a facility that would reveal technical properties of warheads as there are facilities at which warhead manufacturing and fissile material production were co-located.

Because of such secrets, access to some facilities will be limited. Therefore, the treaty will need a provision for the exemption of such facilities from the general verification procedures and for replacing them by special verification provisions, which reduce the intrusiveness of on-site inspections and enhance the significance of containment and surveillance techniques with additional managed access provisions. The following categories of facilities could be distinguished:

- Ordinary facilities included in the normal procedures as defined.
- Former military facilities now used for civilian production at which sensitive information can still be found: on-site inspections at such facilities might take place with less intrusiveness and through managed access provisions. As a consequence, accounting for materials within the facility might not be possible for a certain period. This period, in which the inspected State removes the sensitive information, must be limited and declared. And special access procedures should not prevent accurate accounting of all material on the site.
- Former military facilities now closed at which sensitive information can still be found: verification that no nuclear materials are being produced might be possible with containment and surveillance and additional observation from the outside for a limited period. It must be investigated how much managed access would be possible in cases of strong suspicions. For this kind of facility, design information and knowledge of past production is not necessary, because the verification needs only to ensure that no production takes place after entry into force. This provision might be helpful for those States that do not want to reveal past production to accede to the treaty.
- Sites that store nuclear weapon materials produced prior to entry into force. It is possible to verify that no production is taking place from the outside by environmental monitoring.
- Military nuclear weapon facilities not used for the production of nuclear materials such as refabrication or dismantlement factories: in non-nuclear weapon States, such facilities do not exist. Any verification activity inside nuclear weapon factories will be problematic and probably not possible. However, it is technically possible to monitor fences and verify their integrity. Environmental samples in the vicinity might help to create some assurance that no production of nuclear materials is taking place.

While today it is unclear which, or indeed if any, such facilities will be covered by the treaty, it is nevertheless important for future negotiators to have an overview not only of the types of facilities that could be problematic, but also to obtain a list of possible methods of dealing with them. They must understand which kind of sensitive information would be affected, why it is sensitive, which alternative methods for verification would be possible in case access is not allowed, what is the potential of so-called managed access procedures, and what kind of research is underway into methods of verifying whether a container contains a declared item without revealing its sensitive properties. There should also be a list of various verification arrangements with different levels of intrusiveness and different levels of assurance that these arrangements would create. Not all of this information is clear today. A rare historic experience is a reprocessing plant in the United Kingdom (B205 at Sellafield) that formerly produced fissile material for nuclear weapons and that was later converted and submitted to Euratom Safeguards, 20 years after it was designed. If a study group were to be established to examine the problem of facilities with sensitive information, it should study this and other relevant examples.

Facilities not designed for safeguards

There is another difference between nuclear weapon States and non-nuclear weapon States that creates challenges for verification: in non-nuclear weapon States, as early as the planning stage of a nuclear plant, implementation of safeguards is already taken into account. During construction, design verification takes place. As a consequence, it is much more difficult for operators in a non-nuclear weapon State to pursue unmonitored diversion paths. Plants in non-nuclear weapon States are well understood, and all their potential diversion paths are known and monitored. Typical safeguard features in a plant include so-called "material balance areas" and "key measurement points". A material balance area has physical boundaries, and the handover and transfers of material must be well defined, monitored and documented. Large facilities that handle bulk material, such as reprocessing plants, are usually composed of several material balance areas. At key measurement points, access to the material is possible, and measurements are facilitated, and transfers into and out of a material balance area only take place at these key measurement points. In a facility that is safeguards-friendly, access to the material at other locations is difficult.

In contrast, facilities in States without full scope safeguards might be constructed in a way that the installation of material balance areas and key measurement points will be physically difficult, be it in terms of difficulty of physical access at some points, due to unfavourable construction and organization of material flows, or because of partial contamination. This is especially the case for bulk facilities, such as enrichment and reprocessing plants, which are at the centre of FM(C)T-related production. Such problems, however, seem to be more of a technical nature. Remedies might be costly, but not impossible in principle. In any case, each such facility that will not be shut down but converted to future civilian use will require individual study and negotiation as to how to establish satisfactory verification.

Furthermore, although it may be that past production will not be covered by the treaty, it would nevertheless be useful to have data on the material inside facilities, in order to facilitate measurements of new production. However, it might be difficult to measure an initial inventory of a plant that had been in operation before being subjected to verification. Inside such a plant, there will be various material reservoirs in many different pipes and containers, with difficulties in measuring masses and isotopic compositions. Measurements could be incomplete with high error margins. The documentation of past production might therefore be unsatisfactory and contradictory.

It would be useful for future negotiators to have an overview of the technical features of a converted plant that might be helpful for future monitoring, and of the possibilities for implementing them following entry into force of the treaty. They should also have access to some figures on the limits of accuracy that can be expected. A discussion of the following questions would also be helpful: which measures are necessary to create assurance that no clandestine operation or diversion is taking place in a plant? Would it be helpful to reconstruct the operational history of a plant? Which methods, such as nuclear archaeology, exist for such a purpose? How can commercial secrets be protected?

How do managed access procedures work, and would they be useful for special plants? What differences are there between different plants, such as reprocessing and enrichment plants?

Verifying naval fuel production

Another problem can arise if some States want to keep the option to produce new HEU for military naval fuel. The use of this material cannot be verified using the same procedures that apply to civilian reactors. Therefore, it is unclear how assurance can be created that this HEU is used only for naval propulsion but not for nuclear explosives. Naval fuel mostly stays in a reactor for decades; moreover, the GGE report notes that "there was widespread agreement that the potential diversion of fissile material from non-proscribed uses, such as naval propulsion, posed a threat to the object and purpose of the treaty".

Theoretically, non-nuclear-weapon states under the NPT would also be allowed to withdraw HEU from safeguards for use in military naval vessels: in INFCIRC/153 (§14b), it is stipulated that verification of fuel in a "non-proscribed military activity" will be renounced as long as the nuclear material is used in such an activity. It is, however, unclear how verification that the material is not being used in nuclear weapons would be undertaken. Theoretically, the International Atomic Energy Agency (IAEA) and the State will make an arrangement that identifies "to the extent possible, the period or circumstances during which safeguards will not be applied". But so far, this has never happened.[9] INFCIRC/153 just provides that the verification should follow the HEU up to its insertion into the reactor, and details of this procedure are unclear. The GGE report states only that some experts want to "deal with it directly in the treaty's verification regime". So up until today, it is not clearly defined under which conditions safeguards of the fuel would be interrupted. There are various possibilities: the interruption could be limited only to fuel in the reactor, or it could also be applied to other facilities. Facilities and locations involved in naval fuel production are enrichment plants, fuel fabrication plants, transports, storage facilities and the reactors themselves.

In the case of a FM(C)T, the problem is exacerbated by the high degree of secrecy surrounding naval fuel elements. Only general information is available on its chemical and isotopic composition, and hardly anything is known about the details of naval reactors, very much in contrast to information on civilian research reactor fuels.[10] There are only a few countries that use military naval reactors whose fuel is likely to fall under a future FM(C)T definition of "fissile material". Whether the owners would be willing to declassify some information in order to facilitate verification is unknown.

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9 As an example, INFCIRC/193, which is the specific safeguards implementation agreement between the IAEA and Euratom, is no more specific than INFCIRC/153.

10 Annette Schaper, *Highly Enriched Uranium, a Dangerous Substance that Should Be Eliminated*, PRIF Report no. 124, Peace Research Institute Frankfurt (PRIF), 2013.

It is therefore unclear how verification could create assurance that freshly produced fissile material for military naval purposes is not used for nuclear explosives instead. At fuel factories, at fuel storage sites and during transport special managed access provisions should be worked out, e.g. using containers, tags, and seals. Verification procedures would still have to be developed to ensure that the material is not diverted to other purposes. The goal is to provide assurance as well as to maintain secrecy. There are many unknowns in these scenarios. In case the option for the production of new HEU naval fuel is kept open in an FM(C)T, starting and termination points of verification should be defined more precisely than in INFCIRC/153. For negotiators, an overview of possible verification scenarios could be helpful. The overview should also cover proposals on verification measures, such as managed access, and should cover the problems associated with each scenario, mainly arising from risks of compromised secrecy on the one hand or from a lack of confidence in verification on the other. This problem is one of the trickiest, most unclear, and most sensitive in relation to an FM(C)T.

Verification problems because of black boxes of unverified materials

It is contested whether any fissile material produced prior to entry into force would be covered by the treaty in some way. The GGE report lists many options, and the decision as to which one will be chosen has been left to future negotiators. In case some material is left out of the treaty, which means that its existence will not be verified, some other verification problems might be created. Such unverified stocks produced prior to entry into force are sometimes called “black boxes” of fissile material. Black boxes might cause some special problems for verification of the material covered by the treaty, as illustrated in the following.

Firstly, without accountancy of material produced prior to entry into force, accountancy of the material produced after that date is more difficult. Secondly, verifying non-diversion would be a problem, since States might swap safeguarded and unsafeguarded materials. Thirdly, there are cases when it would be problematic to distinguish between materials produced prior to or after entry into force. This problem arises in plants formerly producing HEU that have been converted to low enriched uranium production. There are very few such facilities.

With regard to the first problem, material accountancy of the total inventory of a State is at the centre of NPT verification, and any inventory change is reported. This method creates a great deal of confidence that any diversion will be detected. However, the GGE report reveals that it is unlikely that this method would be established by the FM(C)T to a similar extent. Nevertheless, it could be possible to establish accountancy of materials produced after entry into force. Verification must then confirm that no such material is diverted for undeclared purposes.

If a State were to swap safeguarded and unsafeguarded materials—the second problem cited—this can be detected as long as the isotopic composition of the accounted material is known, and as long as there is a difference in the isotopic composition of the swapped materials. If the isotopic composition is exactly the same, one might ask whether swapping is a problem at all. It is possible that swapping happened in the past with UK and French civilian and military nuclear materials, which is not a problem as long as the total quantities are not changed. Nevertheless, the probability that swapping could be detected would be enhanced by monitoring the storage sites and transports of direct-use materials produced after entry into force.

The third problem—how to distinguish between materials produced prior to and after entry into force—can be solved by nuclear forensics that determine the ratio between isotopes and their decay products. The feasibility has been experimentally demonstrated for both plutonium and HEU samples with an accuracy of a few years.[11] The lowest detection limits are reported to be in the order of 10^4 to 10^5 atoms.[12] Inspectors normally use environmental sampling techniques in an inspected plant and analyse the isotopic composition. The quantities to be analysed are therefore very small, and since the build-up of decay products in uranium is slow, the analysis methods for HEU must be very sensitive. The analysis is less difficult in the case of plutonium that decays faster. The results of age determination experiments are promising, but it would be helpful if samples of previously fabricated materials were to be available for comparisons. Unfortunately, the nuclear weapon States currently seem unlikely to offer such transparency. It would also be helpful to permanently install portable and continuous enrichment monitors, otherwise detection within a sufficiently short time would not be possible.[13]

These problems need more study. Negotiators would need to have an overview of scientific methods to determine the age of samples of fissile materials, of the precision of methods, and of the limitations of conclusions that could be drawn from measurements. From this, they would be able to deduce realistic requirements for verification that could be included in the treaty. There are scientists who undertake research on such measurements; it would make sense to ask them to assist in such studies as part of the background for negotiations.

11 For plutonium see: Maria Wallenius und Klaus Mayer, "Age Determination of Plutonium Material in Nuclear Forensics by Thermal Ionisation Mass Spectrometry", *Fresenius Journal of Analytical Chemistry*, vol. 366:3, 2000, pp. 234–238; Yan Chen, Zhi-yuan Chang, Yong-gang Zhao, Ji-long Zhang, Jing-huai Li und Fu-jun Shu, "Studies on the Age Determination of Trace Plutonium", *Journal of Radioanalytical and Nuclear Chemistry*, vol. 281:3, 2009, pp. 675–678. For HEU see: A. Glaser, S. Bürger, "Verification of a Fissile Material Cutoff Treaty: The Case of Enrichment Facilities and the Role of Ultra-trace Level Isotope Ratio Analysis", *Journal of Radioanalytical and Nuclear Chemistry*, vol. 280:1, 2009, pp. 85–90; S.P. Lamont and G. Hall, "Uranium Age Determination by Measuring the $^{230}Th/^{234}U$ Ratio", *Journal of Radioanalytical and Nuclear Chemistry*, vol. 264:2, 2005.

12 A. Glaser and S. Bürger, "Verification of a Fissile Material Cutoff Treaty: The Case of Enrichment Facilities and the Role of Ultra-trace Level Isotope Ratio Analysis", *Journal of Radioanalytical and Nuclear Chemistry*, vol. 280:1, 2009, pp. 85–90.

13 Ibid.

Military production of tritium

All modern nuclear weapons use tritium for boosting. Since tritium decays with a half-life of 12.3 years, it must be regularly replaced and newly produced. For this reason, the nuclear weapon States reject a ban or a moratorium on tritium production, and this seemed to be accepted by most GGE members.[14] Even if tritium production is not banned, some problems of verification might arise: all production methods for tritium have in common that they need neutrons.[15] Two methods are applied industrially; some others either need rare source materials or are ineffective. The most common and effective method for military production is breeding tritium from lithium-6 (Li-6) by inserting it into a reactor core or blanket:

$$n + {}^{6}\mathrm{Li} \rightarrow {}^{3}\mathrm{T} + {}^{4}\mathrm{He}$$

The other method makes use of the capture of a neutron by deuterium, as takes place in heavy water reactors like Canada Deuterium Uranium reactors (CANDUs) that are moderated by heavy water:

$$n + {}^{2}\mathrm{D} \rightarrow {}^{3}\mathrm{T}$$

Tritium removal from the heavy water is necessary for decontamination reasons. Furthermore, there are civilian uses of tritium, such as fusion research. Canada, for example, is an exporter of tritium, claiming that it is only for peaceful uses. Although the cross-section for this reaction is smaller than that for the irradiation of Li-6, the mere quantity of the heavy water needed in CANDUs yields large amounts of tritium.

While it is highly unlikely that a ban on tritium production for nuclear weapons will be part of the scope of an FM(C)T, it may nevertheless pose problems for verification because of the neutrons that are needed for its production. Any neutron source, whether reactor or accelerator, can be used for both plutonium or tritium production. Thus, depending on a future definition of what constitutes "production", it might be that any strong neutron source will need to be verified for the non-production of plutonium for weapons.

Indeed, nuclear weapon States used their military production reactors for both plutonium or tritium production. Dismantlement of nuclear weapons has provided enough tritium to enable some nuclear weapon States not to require new production for a while. But plans for a resumption of production are already underway in all nuclear weapon states.[16]

Verification must ensure that no plutonium is produced for undeclared purposes, but it is not necessary for verification to account for the quantities of tritium that may be

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14 The GGE report states: "Most experts agreed that tritium, as it is not by definition a fissile material, should be excluded from the treaty. A few argued it remains an important component in many nuclear weapons and should therefore be considered for inclusion".

15 Described in detail by Martin B. Kalinowski, *International Control of Tritium for Nuclear Nonproliferation and Disarmament*, Science and Global Security Monograph Series, vol. 4, CRC Press, 2004.

16 See Annette Schaper, *A Treaty on Fissile Material: Just Cutoff or More?*, PRIF Report no. 109, Peace Research Institute Frankfurt (PRIF), 2011.

produced in a reactor. However, the fact that tritium is being produced in a reactor cannot be hidden, because Li-6 target rods within the reactor core would be revealed.

Helpful background information for diplomats negotiating a future treaty would include an overview of methods for distinguishing plutonium from tritium production, including a discussion of whether sensitive information would be released by such verification methods. An overview of the characteristics of plutonium or tritium production, respectively, and their typical characteristics, such as effluents released into the environment that could be useful for verification, would also be useful.

Conclusion

The six examples illustrated above show that it would make sense to establish one or several groups of scientific experts to prepare background material that one day could facilitate and accelerate negotiations, in a similar way to the model of the GSE for the Comprehensive Nuclear-Test-Ban Treaty.

In the past, scientific seminars and side events in the Conference on Disarmament dealt with such problems. The most recent ones were organized by Japan and Australia in 2011, and by Germany and the Netherlands in 2012. Several scientists who work on the problems illustrated above spoke at these events, on topics including "verifiable and transparent decommissioning of facilities", "conversion of production facilities that were not designed for safeguards", "the role and limitations of 'nuclear archaeology'", and "FMCT-specific way for managed access". The scientists explained both the capabilities and limitations of the science at the time, and considered the prospects for future developments.

It is time for a new group of scientific experts to be formed. Ideally, the participating scientists should be able to make use of other research capabilities in both their home and other international institutions. They should refrain from discussions of politics and other topics that should be left to the negotiators, and instead carry out scientific work that could be useful for the negotiations.

Towards a Ban on All Production of Fissile Materials that Can Be Used for Nuclear Weapons

Zia Mian

For seven decades, a key part of the effort to end the threat from nuclear weapons has been the idea of an international agreement to constrain, if not eliminate altogether, the production of fissile materials: the separated plutonium and highly enriched uranium (HEU) that are the key ingredients of such weapons. Many of the essential elements of such an agreement, that today is referred to as a Fissile Material Treaty or Fissile Material (Cut-off) Treaty, were spelled out early on but, despite its obvious benefits, progress towards this goal has come in fits and starts. However, the goal may now be within reach.

The Cold War contest between the United States and the Soviet Union blocked movement towards an agreement to ban production of fissile materials for nuclear weapons as both superpowers built up vast arsenals of weapons and associated fissile material stockpiles. In the wake of the Cold War, the size of these arsenals began to fall, and the United Nations General Assembly authorized the negotiation at the Conference on Disarmament of a treaty to ban fissile material production for nuclear weapons. Continuing disputes over both the scope and verification of such an agreement have prevented negotiations from taking place for the past 20 years. The failure to overcome these disputes, most recently the insistence by Pakistan that the scope of the treaty include an obligation to reduce and balance existing fissile material stockpiles, flows from the international community having not given sufficient priority to achieving the consensus required to begin negotiations at the Conference on Disarmament. In the case of Pakistan, the international community, in particular the United States and its European allies, has chosen since 2001 to give greater weight to the war in Afghanistan and the struggle against radical Islamic groups than ending fissile material production for nuclear weapons.

Nonetheless, efforts at the Conference on Disarmament by some States and since 2006 by the non-governmental International Panel on Fissile Materials (IPFM), and in 2013 the establishment of the Group of Government Experts, have enabled the achievement of a growing understanding and a basis for possible agreement among many States on key aspects of a treaty on fissile material production.

This paper examines the evolution of the approach to the nuclear materials and facilities that would need to be controlled as part of a fissile material production treaty. It focuses on how such a treaty might treat the problem of continuing production of fissile materials for non-weapon use, and on the possible verification arrangements in nuclear weapon States where, in particular, the challenge will be faced of former military facilities that these States may wish to keep operating for non-weapon purposes, be they military or civilian. It draws on a longer treatment of these issues in IPFM reports, especially *Global Fissile Material Report 2008: Scope and Verification of a Fissile Material (Cutoff) Treaty*.[1] It also draws on IPFM's proposed draft Fissile Material (Cutoff) Treaty.[2]

The paper builds on developments since 2008, especially commitments by leading States concerning fissile materials, including the undertakings at the Nuclear Security Summits starting in 2010 to ensure "effective security of all nuclear materials" and in the June 2013 Guidelines of the Nuclear Suppliers Group of countries, which emphasized the need "to reduce the risks of proliferation… [through] agreements on supply of nuclear materials or of facilities which produce material usable for nuclear weapons or other nuclear explosive devices".[3] This evolving understanding and interlinked set of obligations concerning fissile materials highlights the fact that the international community is moving towards and should embrace the goal of ending all production of fissile material that can be used for nuclear weapons.

Permitting fissile material production for non-weapon purposes

An early vision of the scope of a possible fissile material production treaty was laid out in 1957 in United Nations General Assembly resolution 1148, which called for a "disarmament agreement" that would include:[4]

(a) "the cessation of the production of fissionable materials for weapons purposes";

(b) "the complete devotion of future production of fissionable materials to non-weapons purposes under effective international control"; and

1 International Panel on Fissile Materials, *Global Fissile Material Report 2008: Scope and Verification of a Fissile Material (Cutoff) Treaty*, 2008, http://fissilematerials.org/library/gfmr08.pdf.

2 International Panel on Fissile Materials, *Draft Fissile Material (Cutoff) Treaty, or FM(C)T*, 2009, http://fissilematerials.org/library/G1060052.pdf.

3 Communiqué of the Washington Nuclear Security Summit, 13 April 2010, http://www.state.gov/documents/organization/237037.pdf; Nuclear Suppliers Group (NSG), *Guidelines for Nuclear Transfers*, June 2013, http://www.nuclearsuppliersgroup.org/images/Files/Updated_control_lists/Prague_2013/NSG_Part_1_Rev.12_clean.pdf.

4 United Nations General Assembly, *Regulation, limitation and balanced reduction of all armed forces and all armaments; conclusion of an international convention (treaty) on the reduction of armaments and the prohibition of atomic, hydrogen and other weapons of mass destruction*, resolution 1148 (XII), 14 November 1957.

(c) “the reduction of stocks of nuclear weapons through a programme of transfer, on an equitable and reciprocal basis and under international supervision, of stocks of fissionable material from weapons uses to non-weapons uses”.

This view of the scope of the treaty as permitting “future production” for “non-weapons purposes” and of redirecting stocks of fissile material originally intended for weapons to “non-weapons uses” reflected optimism evident in some circles in the early years of the nuclear age about peaceful uses of nuclear technology. It was a perspective laid out in the United States Atoms for Peace programme announced in late 1953 and most obviously expressed in the first International Conference on Peaceful Uses of Atomic Energy convened by the United Nations in 1955 in Geneva. It is worth recalling, however, that these visions of widespread peaceful uses of nuclear technology were based more on technological and political hope than real-world experience. The first commercial nuclear power plant was opened in 1956 in Britain, and the United States only began operating its first nuclear power reactor in 1957.

The Cold War arms race prevented progress being made towards a fissile material production treaty. The idea re-emerged in the early 1980s, when the Soviet Union proposed at the United Nations a “cessation of production of fissionable materials for manufacturing nuclear weapons” as an early step in freezing the arms race and towards nuclear disarmament.[5] Again, the implication was that this ban would apply to production of plutonium and HEU for the specific purpose of using it in nuclear weapons. The United States rejected the offer. It took the end of the Cold War to open the path forward.

In 1993, a United Nations General Assembly resolution authorized the Conference on Disarmament to negotiate a fissile material production treaty. Reporting on the 1994–1995 discussions at the Conference on Disarmament on the mandate for an ad hoc committee to negotiate such a treaty, Ambassador Gerald Shannon noted that:[6]

> “many delegations expressed concerns about a variety of issues relating to fissile material, including the appropriate scope of the Convention. Some delegations expressed the view that this mandate would permit consideration in the Committee only of the future production of fissile material. Other delegations were of the view that the mandate would permit consideration not only of future but also of past production. Still others were of the view that consideration should not only relate to production of fissile material (past or future) but also to other issues, such as the management of such material. It has been agreed by delegations that the mandate for the establishment of the Ad Hoc Committee does not preclude any delegation from raising for consideration in the Ad Hoc Committee any of the above noted issues”.

5 Statement by Andrei A. Gromyko, Minister of Foreign Affairs of the USSR, Plenary Meeting of the Second Special Session of the United Nations General Assembly Devoted to Disarmament, 12 June 1982; for a transcript see UN document A/S-12/PV.12, 18 June 1982.

6 Conference on Disarmament, *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*, document CD/1299, 24 March 1995.

It is noteworthy that the Shannon report suggests consideration of "production of fissile material" and does not explicitly limit this to production of fissile material for weapons purposes. Put another way, the scope of the treaty under the "Shannon Mandate" could include restrictions on production of fissile material for any purpose, military or civilian.

Banning production of fissile material that could be used for weapons

The first five decades of thinking about a fissile material treaty focused on the goal of banning the production of fissile material intended for use in nuclear weapons. But today a broader view of this obligation might be necessary and feasible. It may be appropriate for such a treaty to ban production of fissile material *that could be used for weapon purposes*, regardless for whether this material was originally intended for military or civilian use. This view recognizes the technical fact that fissile material that can be used in weapons need not have been produced specifically for that purpose. This view is implicit in the safeguards system of the International Atomic Energy Agency (IAEA) as applied to non-weapon States parties of the nuclear Non-Proliferation Treaty (NPT).

This broader view of a fissile material production ban would have the added benefit that it would make it easier to implement the other basic obligations of such a treaty. In particular, a comprehensive ban would greatly strengthen the obligation not to circumvent the treaty by acquiring or diverting fissile materials from other sources to use in nuclear weapons. It would also prevent States from producing and stockpiling fissile materials that could be used for weapons in anticipation of a possible formal withdrawal or breakout from the treaty. These problems are recognized both by the IPFM and by France in their respective draft treaties. Article 1.2 of the IPFM draft treaty says: "Each State Party undertakes not to acquire from any source or to transfer to any recipient fissile material for nuclear weapons or other nuclear explosive devices".[7] The draft treaty submitted by France in 2015 obliges States "to refrain from using the materials produced thereafter for nuclear weapons or other nuclear explosive devices".[8]

It is now well known that it is possible to make nuclear weapons with reactor-grade plutonium separated from commercial nuclear power reactor spent fuel that have yield, reliability, and weight comparable to those made from plutonium produced for this purpose in a dedicated plutonium production reactor. In 1994, a committee of the United States National Academy of Sciences reported that:[9]

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7 International Panel on Fissile Materials, *Draft Fissile Material (Cutoff) Treaty, or FM(C)T*, 2009, http://fissilematerials.org/library/G1060052.pdf.

8 *French draft for a Treaty Banning the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices*, 2015 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, NPT/CONF.2015/WP.28, 21 April 2015, http://www.francetnp.gouv.fr/IMG/pdf/2015-04-09_projet_traite_fmct_version_finale_eng.pdf.

9 Committee on International Security and Arms Control and National Academy of Sciences, *Management and Disposition of Excess Weapons Plutonium*, National Academy Press, 1994, pp. 32–33, http://www.nap.edu/catalog/2345.html.

> “Virtually any combination of plutonium isotopes … can be used to make a nuclear weapon ... it would be quite possible for a potential proliferator to make a nuclear explosive from reactor-grade plutonium using a simple design that would be assured of having a yield in the range of one to a few kilotons, and more using an advanced design”.

This conclusion drew on classified studies by the United States national laboratories. The National Academy of Sciences committee members later found no significant disagreement with this conclusion from British, Chinese, French and Russian nuclear weapon designers.[10]

In 1997, the United States Department of Energy, which is responsible for the design and production of nuclear weapons, made public a more detailed assessment:[11]

> “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 could build a nuclear weapon from reactor-grade plutonium that would have an assured, reliable yield of one or a few kilotons (and a probable yield significantly higher than that). At the other end of the spectrum, advanced nuclear weapon states such as the United States and Russia, 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”.

In the light of these technical determinations on the potential weapon-usability of plutonium separated from commercial nuclear power reactor spent fuel in civilian reprocessing plants and the lack of an economic justification for civilian reprocessing, it becomes hard to see why any separation of plutonium should be permitted under a fissile material production treaty.

A ban on plutonium separation would affect only a small number of States (see Table 1). The military reprocessing plants in India, Israel, Pakistan and the Democratic People’s Republic of Korea would have to be shut down under a treaty banning fissile material production for weapons. Reprocessing plants that separate plutonium from nuclear power reactor spent fuel that are currently operating in the United Kingdom are already scheduled for shutdown. The plant in the United States is reprocessing spent fuel from research reactors to recover HEU, which is then blended down to low-enriched uranium. China and Japan have plants that are still starting up. The main impact would be on France, since India and the Russian Federation have reprocessing plants with much smaller capacity.

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10 International Panel on Fissile Materials, *Global Fissile Material Report 2007: Developing the Technical Basis for Policy Initiatives to Secure and Irreversibly Reduce Stocks of Nuclear Weapons and Fissile Materials*, 2007, p.125, note 105, http://fissilematerials.org/library/gfmr07.pdf.

11 United States Department of Energy, *Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives*, DOE/NN-0007, 1997, pp. 37–39, www.ipfmlibrary.org/doe97.pdf.

As detailed in the 2015 IPFM report, *Plutonium Separation in Nuclear Power Programs. Status, Problems, and Prospects of Civilian Reprocessing Around the World*, reprocessing spent nuclear fuel also brings additional risks from radioactivity releases to the environment during routine operations and potentially catastrophic releases from accidents or attacks on spent nuclear fuel pools at reprocessing plants (which typically hold spent fuel from many nuclear reactors accumulated over many years) or on the liquid high-level waste created by reprocessing.[12] Even without accidents, reprocessing sites inevitably end up highly contaminated. Finally, a stockpile of separated plutonium is produced that, as noted above, can be used to make weapons.

Table 1. Reprocessing plants, 2015

State	Facility	Type	Status	Capacity (heavy metal tons/year)
China	Lanzhou pilot plant	Civilian	Starting up	50–100
Democratic People's Republic of Korea	Yongbyon	Military	Operational	100–150
France	La Hague UP2	Civilian	Operational	1000
	La Hague UP3	Civilian	Operational	1000
India	Kalpakkam	Dual-use	Operational	100
	Tarapur	Dual-use	Operational	100
	Tarapur-II	Dual-use	Operational	100
	Trombay	Military	Operational	50
Israel	Dimona	Military	Operational	40–100
Japan	JNC Tokai	Civilian	To be shut down	200
	Rokkasho	Civilian	Starting up	800
Pakistan	Chashma	Military	Starting up	50–100
	Nilore	Military	Operational	20–40
Russian Federation	Mayak RT 1, Ozersk	Civilian	Operational	200–400
UK	BNFL B205 Magnox	Civilian	To be shut down	1500
	BNFL Thorp, Sellafield	Civilian	To be shut down	1200
USA	H canyon, Savannah River Site	Civilian	Operational	15

"Capacity" refers to the highest amount of spent fuel the plant is designed to process and is measured in tons per year of heavy metal (uranium) in the spent fuel.[13]

12 International Panel on Fissile Material, *Plutonium Separation in Nuclear Power Programs: Status, Problems, and Prospects of Civilian Reprocessing Around the World*, 2015, http://fissilematerials.org/library/rr14.pdf.

13 International Panel on Fissile Material, *Global Fissile Material Report 2015: Nuclear Weapon and Fissile Material Stockpiles and Production*, 2015, http://fissilematerials.org/library/gfmr15.pdf, Appendix 3.

A case can also be made to ban all production of HEU.[14] HEU is defined by the IAEA as uranium containing 20 per cent or more uranium-235. Natural uranium contains only 0.7 per cent uranium-235.

Along with use in nuclear weapons, HEU is used to fuel naval propulsion reactors, isotope production reactors, as well as breeder reactors and research reactors, and is used in neutron targets for medical radioisotope production (Table 2).[15] The largest of these uses by far is in naval propulsion by the United States, which fuels its nuclear-powered aircraft carriers and submarines with HEU enriched to 93 per cent uranium-235 that was produced originally for nuclear weapon purposes. The United Kingdom receives HEU from the United States for its naval fuel. India and the Russian Federation also use HEU for naval fuel, but typically at enrichments lower than those used by the United States and the United Kingdom.

Table 2. Estimated annual HEU requirements for non-weapon uses

Requirements	Estimated annual HEU use
Naval reactor fuel	4 tons/year (USA, UK, India and Russian Federation)
Isotope production reactor fuel	1 ton/year (Russian Fed.)
Breeder reactor fuel	1 ton/year (weapon-grade equivalent, Russian Fed.)
Research reactor fuel	0.7 tons/year (supplied by USA and Russian Fed.)
Medical isotope production targets	0.04–0.05 tons/year (mostly supplied by USA)
Total	**~ 7 tons/year**

HEU use is estimated in tons per year but when HEU is used as fuel in reactors this reflects an average annual consumption between reactor refuelings, which can be many years apart and in the case for some naval reactors an average annual consumption over the lifetime of the core.[16]

A fissile material production treaty that banned all HEU production would only affect four States. Today, HEU is being produced only by India, Pakistan, the Russian Federation and probably the Democratic People's Republic of Korea. In India, production is predominantly for naval fuel. In Pakistan and possibly in the Democratic People's Republic of Korea, HEU production is believed to be for nuclear weapons. The Russian Federation, which stopped HEU production for weapons, resumed production in 2012 on a small scale to fuel its nuclear power icebreakers, breeder reactors and for research reactor fuel, including for export. It could satisfy these needs from its existing huge stocks but prefers to use its excess enrichment capacity.

14 Frank von Hippel, *Banning the Production of Highly Enriched Uranium*, International Panel on Fissile Material, Research Report No. 15, March 2015, http://fissilematerials.org/library/rr15.pdf.

15 Ibid.

16 Ibid.

The need to reduce the use of HEU—and implicitly to not produce more HEU—was recognized in the 2010 Nuclear Security Summit. The final communiqué declared that States:[17]

> "encourage the conversion of reactors from highly enriched to low enriched uranium fuel and minimization of use of highly enriched uranium, where technically and economically feasible".

At the subsequent Summit in 2012 the official communiqué declared that:[18]

> "We encourage States to take measures to minimize the use of HEU, including through the conversion of reactors from highly enriched to low enriched uranium (LEU) fuel, where technically and economically feasible, taking into account the need for assured supplies of medical isotopes, and encourage States in a position to do so, by the end of 2013, to announce voluntary specific actions intended to minimize the use of HEU. We also encourage States to promote the use of LEU fuels and targets in commercial applications such as isotope production, and in this regard, welcome relevant international cooperation on high-density LEU fuel to support the conversion of research and test reactors".

A ban on all HEU production would require States that use HEU for nuclear fuel and for other purposes to move to LEU fuel or to non-nuclear alternatives. For all non-weapon uses of HEU, moving to LEU or alternative technologies is possible and in some cases is already underway, and it is estimated that not more than a few decades may be required to achieve such a goal.[19] The most difficult shift is expected to be the case of the HEU naval fuel used by the United States and the United Kingdom. In January 2014, the Office of Naval Reactors in the United States National Nuclear Security Administration reported that "the potential exists to develop an advanced fuel system … [which] might … allow using LEU fuel" instead of HEU and that this alternative LEU fuel may take "at least 10 to 15 years" to develop and "at least another ten years beyond that would be needed to deploy a nuclear reactor with this fuel".[20] A fissile material production treaty could therefore ban production of HEU for all purposes.[21]

Simplifying verification

A ban on all production of separated plutonium and of HEU would simplify verification of a fissile material production treaty. Allowing nuclear weapon States to continue

17 Communiqué of the 2010 Nuclear Security Summit, Washington, DC, 13 April 2010, http://www.state.gov/documents/organization/237037.pdf.

18 Communiqué of the 2012 Nuclear Security Summit, Seoul, 27 March 2012, http://www.state.gov/documents/organization/236996.pdf.

19 Frank von Hippel, *Banning the Production of Highly Enriched Uranium*, International Panel on Fissile Material, March 2015, http://fissilematerials.org/library/rr15.pdf.

20 Ibid.

21 Zia Mian, Michael Schoeppner and Frank von Hippel, "Banning the production of highly enriched uranium", *Bulletin of the Atomic Scientists*, 18 March 2016, http://thebulletin.org/banning-production-highly-enriched-uranium9266.

production of these fissile materials in former military production facilities that had been converted to civilian use, or in dual-use (military/civilian) facilities, such as in India, would require identifying and discriminating between tell-tale traces of production of plutonium or HEU that occurred after the treaty entered into force from those dating from before the treaty's entry into force. This would make verification less certain.

A ban on all production of plutonium and HEU would also greatly simplify the issue of what to do about existing and former fissile material production facilities. A treaty should not allow States to retain fissile material production plants that remain ready to resume production of fissile materials for weapons purposes. Article I.4 of the IPFM draft requires that reprocessing facilities and enrichment plants that have been used to produce fissile materials for weapons be shut down and decommissioned and ultimately dismantled or that they be converted to the production of material for civilian or non-weapon uses. Article 3.2 of the French draft imposes a similar obligation.

To a large extent, verification of a fissile material production treaty in nuclear weapon States could be carried out using the safeguards approaches taken by the IAEA to verify non-weapon State compliance with the NPT. The standard inspections (under the IAEA INFCIRC/153 comprehensive safeguards agreement) aim to detect in a timely manner any diversion of declared fissile materials from declared nuclear facilities, while the Model Additional Protocol (IAEA INFCIRC/540) requires expanded reporting, allows investigation of a broader range of nuclear programme activities and permits challenge inspections and the use of environmental sampling to determine compliance. Under a fissile material production treaty, similar monitoring would have to be imposed on nuclear weapon States.

For the purposes of verification, the IPFM draft treaty proposes the following:[22]

> ***Article III.3.*** *States Parties not having a comprehensive safeguards agreement with the IAEA and possessing at least one significant quantity of unsafeguarded fissile material undertake to accept safeguards in an appropriate safeguards agreement to be concluded with the IAEA to verify their obligations under Article I, including:*
>
> ***i)*** *The non-production of fissile materials for nuclear weapons or other nuclear explosive devices and to that end:*
>
> ***a)*** *The disablement, decommissioning and dismantlement of production facilities or their use only for peaceful or military non-explosive purposes, and*
>
> ***b)*** *The absence of any production of fissile materials without safeguards.*
>
> ***ii)*** *The non-diversion to nuclear weapons, other nuclear explosive devices or purposes unknown of:*
>
> ***a)*** *All civilian fissile materials, including in spent fuel,*
>
> ***b)*** *All fissile materials declared excess to any military purpose,*

22 International Panel on Fissile Materials, *Draft Fissile Material (Cutoff) Treaty, or FM(C)T*, 2009, http://fissilematerials.org/library/G1060052.pdf.

c) All fissile materials declared for military non-explosive purposes.

Nuclear weapon States are not covered by IAEA INFCIRC/153 agreements but the five weapon States that are parties to the NPT have concluded restricted Additional Protocol agreements with the IAEA. The Additional Protocol signed by the United States is the closest to the one that applies to non-weapon States, but it allows the United States to protect from inspection “activities with direct national security significance … [and] locations or information associated with such activities”.[23] In particular, nuclear weapon and naval-reactor-related activities are not open to inspection. Under a fissile material production treaty, this exemption (and those in other nuclear weapon States) would have to be addressed so as to enable inspectors to verify that no clandestine production of fissile material was taking place.

The IPFM draft treaty sets as a goal equity in the monitoring of fissile material production in non-weapon States and weapon States. The ultimate purpose of the arms control and disarmament process, including as laid down in the NPT, is for all States to become non-weapon States. Japan is the only non-weapon State that has an active plutonium separation programme and no non-weapon State produces HEU.

Legacy military reprocessing and enrichment facilities in nuclear weapon States would pose a problem for any system of inspections under a fissile material production treaty. Reprocessing plants in China, the Democratic People’s Republic of Korea, India, Israel, Pakistan, the Russian Federation and the United States were not designed to be inspected and are already heavily contaminated, making some parts closed to inspection. A ban on all plutonium separation would require these facilities to be shut down in order to remove possible concerns about the comprehensiveness and completeness of the verification system.

The situation with regard to uranium enrichment plants is different. If former military enrichment facilities were repurposed for civilian uses but allowed to continue producing HEU for non-weapon purposes, verification would require monitoring all such production and tracking all such material produced over the lifetime of each facility. Managed access arrangements would be required at former military enrichment facilities to provide inspectors with the opportunity to verify that the HEU was not being diverted. Problems for verification in such plants would be that design information verification would be difficult in old facilities, that these facilities were not designed for international monitoring, and that the plants could be contaminated with traces of HEU from previous production that would make it hard to identify traces of any new production taking place after the treaty entered into force. Tracking HEU after it was produced would be complicated but theoretically possible if the HEU were to be used, for instance, in military

23 Protocol Additional to the Agreement Between the United States of America and the International Atomic Energy Agency for the Application of Safeguards in the United States of America, www.ipfmlibrary.org/gov98.pdf.

naval propulsion.[24] Similar arrangements could work for military reactors that use HEU to produce tritium for nuclear weapons.

Verification would be much simpler if former military enrichment plants were shut down and replaced where necessary with new plants designed for verification and able to produce only LEU. Conversion of former military HEU enrichment plants so that they could produce only LEU may leave in place plant infrastructure that could allow them quickly to revert to HEU production. The goal of enrichment plants built on the principles of being able to produce only LEU and of verification by design was accepted in the June 2013 Guidelines of the Nuclear Suppliers Group (NSG), whose members include China, France, the Russian Federation, the United Kingdom and the United States.

The 2013 NSG Guidelines on enrichment plants state:[25]

> Article IV (a): "For a transfer of an enrichment facility, or equipment or technology therefor, suppliers should seek a legally-binding undertaking from the recipient state that neither the transferred facility, nor any facility incorporating such equipment or based on such technology, will be modified or operated for the production of greater than 20% enriched uranium. Suppliers should seek to design and construct such an enrichment facility or equipment therefore so as to preclude, to the greatest extent practicable, the possibility of production of greater than 20% enriched uranium".

> Article IV (e): "For a transfer of an enrichment facility, the supplier and recipient state should work together to ensure that the design and construction of the transferred facility is implemented in such a way so as to facilitate IAEA safeguards. The supplier and recipient state should consult with the IAEA about such design and construction features at the earliest possible time during the facility design phase, and in any event before construction of the enrichment facility is started".

These requirements could be made applicable to all enrichment plants under a fissile material production treaty.

Conclusion

A fissile material production treaty has traditionally been understood as ending the production of fissile material intended for nuclear weapon purposes. This understanding was implicit in the 1995 Shannon Mandate that sought to establish the conditions that would enable negotiations to begin at the Conference on Disarmament. The mandate did, however, leave the matter of scope open to negotiation. In the 20 years since the Shannon Mandate, independent analysis, and arguments, declarations and commitments

24 Sebastien Philippe, "All at Sea? A Safeguards Approach for the Military Naval Nuclear Fuel Cycle", 55th Annual INMM Meeting, 20–24 July 2014, Atlanta, Georgia; Sebastien Philippe, "Bringing law to the sea: safeguarding the naval nuclear fuel cycle", *Bulletin of the Atomic Scientists*, 4 September 2014, http://thebulletin.org/bringing-law-sea-safeguarding-naval-nuclear-fuel-cycle7418.

25 Nuclear Suppliers Group (NSG), *Guidelines for Nuclear Transfers*, June 2013, http://www.nuclearsuppliersgroup.org/images/Files/Updated_control_lists/Prague_2013/NSG_Part_1_Rev.12_clean.pdf.

made by States have highlighted the need to focus attention and controls not just on fissile material produced with the intent to make nuclear weapons but on all fissile materials that could be used to make nuclear weapons. This new view of fissile material control opens the door to consideration of a fissile material treaty that bans all production of fissile material that could be used to make nuclear weapons.

A ban on all separation of plutonium and all production of HEU (and of any other fissile material that can be used to manufacture nuclear weapons) would affect only a small number of States. These materials have limited use other than in weapons: these uses are mostly as reactor fuels. The separation of plutonium for use in reactor fuel is not economic. Alternatives to the non-weapon uses of HEU already exist or are under development and could be realized within, at most, a few decades. Such a ban would facilitate verification of a fissile material production treaty, easing in particular the problem of monitoring former military fissile material production plants. A simple and robust solution would be to shut down all such reprocessing and enrichment plants. Any State wishing to have a uranium enrichment plant for civilian purposes should be required to design it so that it is verification-friendly and not able to produce HEU, to the extent possible. This would be a significant step towards establishing equality in the obligations concerning fissile material production in nuclear weapon and non-weapon States.

FM(C)T: Elements of the Emerging Consensus: Summary of the Discussion

Pavel Podvig

The discussion that followed the presentations touched on a number of issues, but three themes figured most prominently—the need for international scientific cooperation to address technical aspects of the future treaty, the role of civilian nuclear industry in the fissile material cutoff regime, and the link between the cutoff of fissile material production and nuclear disarmament.

Work on technical aspects of the treaty

Participants in the discussion generally backed the idea of devoting more effort to scientific research in support of FM(C)T goals. Although the international expert community has made significant progress in understanding the problems associated with treaty verification, there are a number of issues that need to be explored further. It was noted that it would be particularly important for the work on technical aspects of the treaty to continue while the Conference on Disarmament focuses on starting the negotiations.

The discussions in the Group of Governmental Experts[1] and the draft treaties that have been submitted to the Conference on Disarmament[2] have demonstrated that in most cases the future treaty could use the extensive experience of the International Atomic Energy Agency (IAEA) in safeguarding nuclear materials. At the same time, these

1 The Group was established pursuant to paragraph 3 of General Assembly resolution 67/53, on the Treaty Banning the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices. The Group's report was issued as UN document A/70/81, 7 May 2015.

2 "Draft Treaty Banning the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices Submitted by France", April 9, 2015, http://www.delegfrance-cd-geneve.org/IMG/pdf/2015-04-09_projet_traite_fmct_version_finale_eng.pdf; "Official Text of the IPFM Draft FM(C)T as Submitted to the United Nations Conference on Disarmament," *International Panel on Fissile Materials*, 30 June 2010, http://fissilematerials.org/library/2010/06/official_text_of_the_ipfm_draf.html

discussions have shown that there are a number of areas that may not be adequately covered by the existing IAEA practices. The key issues are downstream verification of material produced for military purposes, especially in the naval fuel cycle, arrangements for managed access at defense-related production facilities, and detection of undeclared activity in States with history of substantial fissile material production for weapons.

A number of participants cautioned against placing too much emphasis on the technical side of the treaty and rather suggested that most of the issues that hold back the FM(C)T negotiations are political rather than technical in nature. For example, the reluctance of nuclear States to open their facilities or their stocks to intrusive verification appears to be largely a political position that is unlikely to change even if a technical solution, such as managed access procedures, is found. The discussion that followed, however, showed that while the nature of the political challenges facing the treaty is well understood, it is still extremely important to support technical work on all aspects of the treaty.

Technical work is essential for reaching shared understanding of the capabilities and limitations of the technical solutions that may be included in the treaty. A more detailed discussion on a number of technical initiatives and projects would be beneficial. One specific example that was mentioned is the Trilateral Initiative, a joint US-Russia-IAEA project to develop techniques and procedures for submitting military-origin fissile material to IAEA safeguards. Some participants suggested that this project is an extremely useful demonstration of a practical approach to verification of military material and may provide a template for some verification procedures. Others argued that this effort is irrelevant in the FM(C)T context, as the procedures developed by the Trilateral Initiative have certain features, such as the use of an information barrier to mask the measurement of mass, that may limit their effectiveness in the FM(C)T context. International collaboration among scientific experts would be very effective in bringing clarity to this and other technical issues.

Another important reason to actively pursue technical work is that new technical solutions may expand the range of political options and create an opening for a political compromise. The specific example that was mentioned during the discussion is the problem of making a complete verifiable declaration of fissile material stocks. It was pointed out that a declaration of this kind would be impossible in practice as it would have to cover the material in active nuclear warheads and would therefore be unverifiable. There are, however, technical approaches to declarations that could address this issue, albeit at the cost of deferring verification to a later date. Whether or not negotiating States ultimately find this kind of solution politically acceptable, it is important to make sure that they have a full range of options to consider concerning approaches to declarations.

A number of participants supported the idea of creating a Group of Scientific Experts, nominated by governments, that would work on common understanding of technical aspects of an FM(C)T and develop new approaches to specific verification challenges of the future treaty.

The civilian nuclear fuel cycle and continuing production of fissile materials

The fissile material treaty was never intended to constrain peaceful nuclear activities or, indeed, production of fissile materials for non-proscribed military purposes. At the same time, the nature of fissile material production invites additional scrutiny of the civilian nuclear industry and of non-weapon uses of weapon-grade fissile materials. Further complicating the matter is the fact that the same technologies are used in civilian and military production cycles. In some cases, civilian and military production cycles are tightly integrated (or were integrated in the past).

In the course of the discussion, a number of participants expressed the view that FM(C)T arrangements should assume that production of weapon-usable fissile materials will continue, and therefore build verification mechanisms that would take into account various fuel-cycle configurations that may exist in different countries as well as the continuing use of fissile materials in non-weapon military applications. This means, for example, that the treaty would have to make arrangements for verification of fuel cycle activities that may include large-scale reprocessing of spent nuclear fuel, operation of breeder reactors, or production of highly-enriched uranium for civilian applications. Similarly, the treaty would have to create a verification mechanism that would cover production of highly-enriched uranium for naval reactors.

This position appears to have support of most participants of the FM(C)T discussions held in the expert community or in the context of the Conference on Disarmament and the Group of Governmental Experts. The treaty would most likely include provisions that allow continuing production even if these provisions are never actively used. At the same time, there was some interest in the proposal to discontinue production of weapon-usable fissile materials for all purposes, not just for nuclear weapons. This would include cessation of plutonium separation activities and a limit on the enrichment of uranium produced at civilian enrichment plants. These measures would make the FM(C)T regime much stronger by simplifying verification procedures and closing off the most serious material diversion possibilities. At the same time, it was argued that the impact of these measures on the civilian nuclear industry would be minimal, since separation of plutonium may not be an essential element of a sustainable civilian nuclear fuel cycle. Similarly, even if production of highly enriched uranium is discontinued, existing stocks of the material would be sufficient to support operations of naval and research reactors for decades. This time could be used to convert these reactors to low enriched uranium fuel.

Even though it may be too early to consider a comprehensive ban on production of weapon-usable materials, the discussion showed that the FM(C)T negotiations will inevitably raise questions about civilian nuclear activities and that certain limits on these activities may strengthen the treaty.

An FM(C)T and nuclear disarmament

Presentation of the possible elements of the FM(C)T led to a discussion of the broader issue of the role that a ban on fissile material production could play in nuclear disarmament. A number of participants supported the view that the FM(C)T negotiations should focus on the narrow issue of stopping future production of fissile materials for weapons. In this view, an effort to broaden the scope of FM(C)T and turn it into an instrument of arms control and disarmament would only complicate the negotiation process and may weaken the future treaty. On the other hand, the work of the Group of Governmental Experts as well as the comments submitted by States before the GGE commenced its work demonstrate that there is strong support for an FM(C)T that would address the issue of existing stocks and include some arms control and disarmament measures. Even though there is no universal agreement on the substance of these measures, it is clear that a number of States would like to see the FM(C)T as an arms control and disarmament instrument, especially given that it would the only multilateral treaty that could potentially impose obligations on all nuclear-armed States.

The issue of finding the right balance between the positions of those who want the FM(C)T to be a disarmament tool and those who see a more limited treaty can be most reliably done during negotiations, when States clarify their positions and priorities. In the absence of negotiations it is difficult to say what this balance will be.

At the same time, it was also noted that the FM(C)T will inevitably create a disarmament mechanism, even if the treaty scope will be limited to future production. An effectively verifiable treaty will have to create verification arrangements that would ensure non-diversion of newly produced fissile materials, whether civilian or military, to nuclear weapons. Once this verification mechanism is in place, it could be used to handle fissile materials from existing stocks (military as well as civilian) or the material that is extracted from dismantled nuclear weapons. This does not necessarily require the FM(C)T to include specific obligations regarding existing stocks or a commitment to submit disarmament material to verification—these obligations could be the subject of separate agreements.

There are, of course, advantages of including disarmament obligations in the FM(C)T. At the same time, it should be understood that even a limited treaty would provide an effective mechanism that could support nuclear disarmament.

Conclusion

Overall, the discussion showed that recent developments, namely the work of the Group of Governmental Experts and the introduction of the draft treaty text by France, have substantially advanced the debate on the key issues of a fissile material cutoff regime. Differences remain, but there seems to be an agreement on the general structure of the future treaty. At this point it should be possible to move the discussion to the stage of developing practical, technical solutions that would help address the outstanding issues.

UNIDIR

FM(C)T Meeting Series

FM(C)T: Elements of the Emerging Consensus

The 2016 UNIDIR FM(C)T Meeting Series explored in depth the issues that were identified in the course of the discussions held at the Group of Governmental Experts that considered aspects of a future treaty. The objective of the series is to help all participants of the FM(C)T deliberations to examine the challenges as well as the technical solutions that may be available to address them. This report presents the first meeting of the series, which examined the structure and basic elements of the treaty, future directions of research in support of the treaty, and a potential ban on production of all weapon-usable fissile materials.