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A Treaty on Fissile Material: Just Cutoff or More?

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Summary

This report describes the significance of a Fissile Material (Cutoff) Treaty (FM(C)T), its most important elements, the major areas of contention and the prospects for progress. Its purpose is mainly to serve as a background for negotiators, decision makers and analysts who are interested in nuclear arms control.

The FM(C)T is a treaty that does not yet exist but that is as important as the Comprehensive Treaty Ban Treaty (CTBT). It shall limit or reduce the quantities of fissile material for nuclear weapons. It is called Fissile Material Cutoff Treaty (FMCT), or Fissile Material Treaty (FMT), depending on the idea of what its scope should be, whether it should cut off only future production or whether it should also include regulations on already existing materials. It was expected for years that the Conference of Disarmament (CD) would negotiate this treaty, as it successfully negotiated the CTBT. But since 1996, the CD has been deadlocked. Since all its decisions are made by consensus, including its work program, one single opponent can not only block all progress but also any work at all. This has happened year after year. Not only is there no consensus on the beginning of the negotiations, but also concerning almost all aspects of the treaty which have been heavily disputed for years.

The idea of limiting the production of fissile material for nuclear weapons traces back to the so-called *Baruch Plan* of 1946. In 1994, many delegations wished to start negotiations in the CD immediately after the end of the CTBT negotiations. It soon became clear that there was disagreement concerning the scope of the treaty. Several delegations wanted to include provisions on already existing fissile material, but several others categorically rejected this idea. The so-called Shannon-Mandate lays out a compromise which reserves the option of including existing stocks or not.

Contrary to the expectations, the CD was unable to agree on a work program in the following years. The reason is the abuse of the rules of the CD which makes decisions by consensus, not only on substance but also on procedural questions. Furthermore, every year, all procedural decisions are discarded, and the CD must start anew to find a consensus on a Work Programme. Over the years, the delegations which have blocked progress varied. Currently, the most visible delegation is Pakistan, which insists on including stocks. The situation today can be traced back to lessons learned from the CTBT negotiations.

The FM(C)T will have many benefits, on which different states place different emphasis. First of all, it would at least be a theoretical symbol of an end to the arms race and would strengthen the Non-Proliferation Treaty. Secondly, rights and duties would be the same for all parties, and thus reduce the discrimination that is inherent in the NP regime. Thirdly, it has the potential to draw in the states outside the NPT. Fourthly, international duties promote a culture of responsibility and transparency, by which the risk of illegal diversion may be reduced.

In order to negotiate on formulations of the treaty text, especially on its scope and on provisions for verification, it is useful to have a common language by using agreed-upon definitions. A helpful technical categorization of fissile material is their usefulness for nuclear explosives, irrespective of their actual use. The IAEA has provided such defini-

tions in order to regulate safeguards provisions. Another categorization, according to the actual use, is needed to negotiate and regulate the scope. It should distinguish between fissile material under safeguards, civilian fissile material and fissile material declared as excess to defense needs but not yet under safeguards, fissile material considered excess to defence needs but not declared so, naval fuel, and fissile material in use for nuclear explosives. The term "production" can be understood in a narrow or a broad sense, depending on whether irradiation in reactors is included or not.

The scope of an FM(C)T is heavily contested. But between the two extremes – no regulations on materials produced prior to entry into force (EIF) or a ban on the possession of any non-safeguarded materials – there are many variations. Examples are irreversibility of disarmament by a ban on re-designation of fissile material to explosive needs; declarations of excess materials produced prior to EIF, or a ban on production of highly enriched uranium (HEU) for naval use.

Just as there are many variations of scope, there are also many verification scenarios, extending from just a fence around former military reprocessing and enrichment facilities to intrusive global concepts. In order to ensure *credibility*, verification must thus not only cover non-production but also non-diversion. This is equal to what is already being verified in non-nuclear weapon states (NNWS) under full-scope safeguards. The difference is the "black box" of non-safeguarded fissile material produced prior to EIF, that the NWS will eventually be allowed. The treaty is intended to be *non-discriminatory*. This means that all rights and obligations for verification should apply equally to all member states. It is clear that there are still difficulties to be overcome. They should be viewed with both patience and eagerness for cooperation towards a common goal. It must be defined which levels of assurance of compliance will be considered satisfactory. Such definitions should be expressed as probabilities for detecting violations.

Three examples of verification scenarios with varying intrusiveness and precision are discussed: Firstly, the focused approach that verifies only those facilities whose output is unirradiated direct-use material, secondly, verification of all facilities whose output is any direct-use material, and thirdly comprehensive verification that also includes special fissionable material production

There are several problems that are specific to the FM(C)T and the existence of non-safeguarded materials and installations. The first is the need for the detection of clandestine production that is more difficult in the case of facilities to which access is limited. The second is the fact that some former production facilities in nuclear weapon states contain secrets. Special verification provisions for such facilities which reduce the intrusiveness of on-site inspections will be needed. Thirdly, the NWS may possess facilities that are not designed for safeguards. If they will be used for future civilian production, installation of verification might be more costly. Fourth, another problem could arise if some states want to keep the option of producing new HEU for naval fuel. Fifth, special verification need would arise if states still possess black boxes of unverified materials. Accountancy would be more difficult, as would be verifying non-diversion, and it would be more difficult to distinguish between materials produced prior or after EIF. Sixth, it is likely that NWS will continue to produce tritium for nuclear weapons. Verification must ensure that this is not confused with plutonium production.

These problems call for detailed further studies. The studies that are necessary for an FM(C)T verification could be started by an independent Group of Scientific Experts, with a mandate limited to technical problems. The willing nations should consider negotiating the treaty outside the CD.

Contents

1. Not much progress in multilateral nuclear arms control

Several international treaties have beneficial impacts on the non-proliferation of nuclear weapons, most prominently the Non-Proliferation Treaty (NPT). A famous nuclear arms control treaty that is not yet in force but nevertheless unfolds effects is the Comprehensive Test Ban Treaty (CTBT).[1] It is the basis of a strong norm against nuclear testing that emerged during the CTBT-negotiations from 1994 to 1996.

A treaty that does not yet exist but that is as important as the CTBT is a treaty to limit or reduce the quantities of fissile material for nuclear weapons. It is called Fissile Material Cutoff Treaty (FMCT), or Fissile Material Treaty (FMT), depending on the idea of what its scope should be, whether it should cut off only future production or whether it should also include regulations on already existing materials; and it has been pursued at least since 1993. The quantities of weapon-grade fissile material amount to more than a thousand tons, sufficient for many tens of thousands of warheads. As suggested by the International Panel on Fissile material (IPFM), I choose to use the abbreviation FM(C)T, in order to acknowledge both views.[2]

While the CTBT can be regarded as a tool to cap the qualitative nuclear arms race, e.g. to hinder the future development of qualitatively new nuclear explosives, the FM(C)T can be seen as its quantitative counterpart, capping the amount of material available for new nuclear weapons. It would be a symbol for the end of the arms race and it would also provide tools necessary for further nuclear disarmament.

The proposal of a cutoff was supported by many UN General Assembly resolutions as a prerequisite for nuclear disarmament, but it has never become as famous and significant as a nuclear disarmament symbol as the CTBT. The reason is not that it is less significant for nuclear disarmament than a test ban, rather there are various explanations: Firstly, it is more closely affected by civilian commercial interests. Secondly, the interests that different nations put into this treaty are widely diverging. Thirdly, the substance of the matter is inherently interdisciplinary: Not only deep technical understanding is required, but also skills in international law and politics. Finally and simply, fissile material production is not a spectacular and unambiguous event that can cause headlines and outrage like a nuclear explosion. A treaty on fissile material is therefore less famous and more complicated than a test ban, but it is at least as important to nuclear disarmament.

For years, it was expected that the Conference of Disarmament would negotiate this treaty, as it has successfully negotiated the CTBT. But since 1996, the Conference on Disarmament (CD) has been deadlocked; the initial optimistic mood soon faded and has been replaced by torpidity. Since the CD makes all decisions by consensus, including its work program, one single opponent can block not only all progress but also any work at all. This has happened year after year since 1996. The most visible actors who blocked progress varied over the years, but there has always been at least one. The respective rea-

1 Schaper 1997.

2 IPFM 2008.

sons vary and might be speculated on; they include disagreement with the positions of the most powerful participants, or the desire to press for concessions in other areas for which the delegation holds the CD hostage.

But not only expectations concerning a start of the negotiations have been disappointed, also almost all aspects concerning the treaty have been heavily disputed for years: The disputes start with the fundamental goals that such a treaty could serve, they continue with its scope, and they do not end with its verification. At the time of writing, the negotiations have not yet begun.

This report describes the significance of an FM(C)T, its most important elements, the major areas of contention and the prospects for progress. Its purpose is mainly to serve as a background for negotiators, decision makers and analysts who are interested in nuclear arms control. It is a snapshot of the situation at the end of 2011, and therefore, only preliminary conclusions can be drawn. Although I do not hide my personal preferences, I try to illustrate options in a way that will hopefully also be helpful for readers who disagree with certain opinions of mine.

1.1 History and politics

1.1.1 Early proposals

Originally, a cutoff of fissile material for weapons was part of a proposal of the U.S. in 1946, the so-called *Baruch Plan*, which aimed at implementing a strong control regime for fissile material, but never became reality. It was next proposed by India in 1954, together with proposals for world-wide nuclear disarmament and a nuclear test ban treaty.[3] But the proposal did not get any reaction; it was rejected by the U.N. General Assembly without any further discussion. It was proposed again by Eisenhower in 1956, but refused by Moscow, based on the argument that it was only a tactic to perpetuate an inferior Soviet status.[4] In 1957, the UN General Assembly, in its Resolution 1148, called for the cessation of fissile material production for nuclear weapons. Mikhail Gorbachev made a similar proposal in 1989, but it was rejected by George H.W. Bush. Since 1978, the proposal was supported by many UN General Assembly resolutions as a prerequisite for nuclear disarmament, but in contrast to the fame of a CTBT, it was treated rather as a wallflower.

The turning point in the U.S. rejection of an FM(C)T came on September 27, 1993, when President Clinton addressed the UN General Assembly proposing a multilateral agreement to halt production of highly enriched uranium (HEU) and separated plutonium for nuclear explosives or outside international safeguards.[5] This led to a UNGA

3 Cortright/Mattoo, Indian Public Opinion and Nuclear Weapons Policy, in: Cortright, D./Mattoo, A. (Eds.), India and the Bomb, University of Notre Dame Press, 1996.

4 Fetter/von Hippel 1995.

5 New York Times, September 28, 1993, p. A16.

resolution calling for the start of negotiations on a non-discriminatory and universal cutoff convention on December 16, 1993.[6]

In the early 1990s, other nuclear arms control activities had a much higher priority, namely the CTBT and the review and extension conference of the NPT which adopted the Principles and Objectives for future reviews.[7] They explicitly list a non-discriminatory and universally applicable FMCT, together with the CTBT, as nuclear disarmament measure that must be successfully pursued. This was the last impetus that irreversibly put the topic on the nuclear arms control agenda. Similarly to the CTBT, an FM(C)T has finally also become an explicit symbol for comprehensive nuclear disarmament, and the attention given to it is regarded as an indicator of how seriously this ultimate goal is being taken.

The interests of the official nuclear weapon states in an FMCT seemed to converge. Such a treaty would consolidate the status quo which had almost been achieved: the U.S., the UK, Russia, and France all announced that they have ceased production of plutonium and HEU for weapons purposes. Up to this day, they see advantages in preventing an accumulation of fissile material in other countries. China has indicated unofficially that it has ended production of fissile material, but has not yet made a formal commitment.

1.1.2 The Shannon mandate

In 1994, the CD started to negotiate on a mandate for an Ad-Hoc Committee on a fissile material cutoff treaty.[8] But from the beginning, it struggled with difficulties. The central dispute was whether the mandate should refer to existing unsafeguarded stockpiles of fissile material or not. Although the UNGA resolution only refers to banning future production of material, Algeria, Egypt, Iran, and Pakistan held out for an explicit reference to stockpiles. Also, a group of non-aligned states had jointly and repeatedly called for a fissile material cut-off to include declaration and control of existing stocks, advocated as well by several Western and Eastern European states concerned about proliferation and nuclear terrorism. Indeed, because of nuclear arms reductions, both the U.S. and Russia held excess nuclear material whose disposition was deemed an important task.

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6 UN General Assembly, 48th Session, First Committee, Agenda item 71 (c), November 8, 1993.

7 Fischer/Müller 1995.

8 The CD adopts its own Rules of Procedure and its own agenda by consensus. An ad-hoc committee is a forum within the CD for negotiations with an agreed mandate.

But Israel and India, as well as France and the UK, indicated that they would not enter into negotiations that would address their existing stocks. The U.S. also rejected the reference to stockpiles. Its major interest was to draw the states outside the NPT into some binding commitments. Pakistan was at the forefront of those insisting to also negotiate on stocks, mainly because of India's larger stocks and its perceived inferiority in this regard. Also many other delegations found it important to at least ensure that no civilian material could return into the military cycle. However, for the sake of getting started, they would have accepted any mandate text, provided that it did not prejudice a treaty scope beforehand.

Finally, on 23 March 1995, the Canadian Ambassador Shannon presented a carefully crafted text announcing that a consensus had been reached to establish an ad-hoc committee with a mandate based on the UNGA text, and the CD adapted this mandate. Although this mandate did not refer to stockpiles, the text explicitly states that discussions on the appropriate scope of the treaty are not excluded, and it also mentions the questions raised by some delegations regarding past production. It explicitly states:[9]

> "The Conference directs the Ad Hoc Committee to negotiate a non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices. … 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."

1.1.3 A series of stalemates

However, the CD was overburdened by the CTBT work, so the negotiations were delayed.[10] At the end of the year, the mandate had expired, and after the completion of the CTBT negotiations in 1996, the situation changed and the CD got stuck in its first stalemate. Key to this stalemate was India: Most of India's demands during the negotiations had been maximalist, namely nothing less than phased elimination of nuclear weapons within a time-bound framework. It was clear that this went far beyond of what is perceived a CTBT, and – not surprisingly – many delegations rejected such demands. India also made some moderate and reasonable proposals, but some diplomats made the mistake of rejecting even those, and so none of the Indian proposals had been included in the draft CTBT text.

India felt snubbed and it refused to re-establish an Ad-Hoc Committee on fissile material, unless there would also be talks on the phased elimination of nuclear weapons within a time-bound framework. This time, India even seemed unwilling to cooperate on the start of any negotiations, in contrast to the start of the CTBT negotiations in 1994.

9 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, www.reachingcriticalwill.org/political/cd/shannon.html (16.12.2011).

10 The developments in the CD have been described and analysed in many articles by R. Johnson in the journal Disarmament Diplomacy. For a detailed overview and analysis of the events until 2006 see Rissanen 2006. For recent developments see Paul Meyer 2009.

The nuclear weapon states, however, were unwilling to agree to any negotiation forum on comprehensive nuclear disarmament.

The Indian maximalist approach was shared by only a few other delegations, whose number crumbled further. In 1998, the situation changed, because India and Pakistan conducted nuclear tests for which they were openly criticized. Claiming the status of a nuclear weapon state and being pressured by many delegations, India dropped its demand for a linkage to nuclear disarmament. So at the end of 1998, an Ad-Hoc Committee was set up, but it only worked for a few weeks during the rest of that year's session.

However, in the following years, the CD was again unable to agree on a work program. This time, China, increasingly concerned about U.S. missile defense plans that it viewed as potentially jeopardizing its deterrence capabilities, insisted on negotiating not only on an FM(C)T but also on establishing another Ad-Hoc Committee on limiting the arms race in outer space. This was rejected by the U.S., and a pass the buck game evolved: Each side blamed the other of blocking progress. Other delegations tried to suggest compromises such as at least discussing or considering issues of outer space in vain for several years.

In 2003, however, China announced its willingness to compromise. But instead of rapidly engaging in negotiations, the Bush administration first started a review process of its interest in an FM(C)T. In 2004, the U.S. announced that it considered an FM(C)T "not verifiable in a meaningful way" and that it no longer adhered to the Shannon mandate which includes the term "effectively verifiable". However, it failed to substantiate this claim. Oral briefings remained unsatisfactory, and were never backed in a written form. The arguments that the U.S. raised orally in various international fora and consultations are the special verification challenges that the FM(C)T poses. They are listed and discussed further below in section 5.4. In 2006, the U.S. tabled its own short draft for an FMCT that did not refer to verification and certainly not to the inclusion of fissile material produced prior to entry-into-force (EIF). Some delegations compromised and backed this proposal, but many others insisted on the Shannon Mandate, including several Western delegations. Not surprisingly, consensus was not achieved and the CD remained blocked.

Some delegations proposed compromises, among them Germany which suggested a "phased approach" towards the goals, by starting with declarations of commitments towards fissile material controls in a first phase, a framework treaty with the general goals in a second step, and a detailed protocol in a third step.[11] Berlin also endorsed a proposal of a Fissile Material Control Initiative (FMCI) "conceived as a voluntary, multilateral arrangement open to any country possessing fissile material", tabled by a U.S. think tank.[12]

The expectations were high when the new U.S. President Obama entered office in 2009. And indeed, his administration revised the U.S. position towards favoring verifica-

11 "Creating a new Momentum for a Fissile Material Cut-Off Treaty" Working paper submitted by Germany to the Second session of the Preparatory Committee for the 2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, Geneva, NPT/CONF.2010/PC.II/WP.21, 30 April, 2008.

12 Robert Einhorn, Fissile Material Control Initiative, A CSIS Proposal, Center for Strategic and International Studies (CSIS), December 2007.

tion. The CD managed to agree on a Programme of Work, but it did not manage to establish an Ad-Hoc Committee.[13] Objections were made by Pakistan, which stressed that the strategic balance in its region had been upset by a new Indian-U.S. nuclear cooperation that allowed India to accelerate the production of its fissile material and increase the gap between the two countries. The treaty would only manifest the current inequality and put a cap on Pakistan. It regards the Shannon Mandate as not sufficiently clear on existing materials. Since then, it has not even been possible to repeat the success of 2009 and to agree just on a Programme of Work.

The old conflict on whether existing material should be included had resurfaced. It had been lingering over the years and was only covered up by other stalemates. The demand to include existing materials is shared by many, who believe that otherwise the disarmament component of the FM(C)T would not be adequately served. A treaty that merely bans future production would only serve nonproliferation, by limiting the production of newcomers, but it would leave the nuclear weapon states (NWS) with huge quantities of fissile material that would allow them any rearmament at any time. The NWS, except Pakistan, insist that already existing material should not be included.

In sum, at the time of this writing, the CD was deadlocked again, as usual. There have been several reasons for and actors in the various deadlocks during the long time of CD inactivity, and most of them existed more or less in parallel throughout the whole period. At a given time, usually just one actor was visible, but others were hiding behind his back.

Conflicts at the outset of a negotiation are in the nature of the matter, but it is absurd if, instead of inducing attempts to solve them, they cause the contrary, namely a block of any activity. The reason for this paradox lies in the rules of the CD that have evolved historically. According to these rules, the CD takes decisions by consensus, not only on substance but also on procedural questions. Furthermore, every year, all procedural decisions are discarded, and the CD must start anew to find a consensus on a Work Programme. Meanwhile, the CD has 65 members, and every single member has a veto, which it can use for any reason, be it national interests, a tool to blackmail the international community in the hope of being bribed, or revenge for a perceived injustice, for an actually existing inequality, or for wounded pride. But rules should facilitate, not impede negotiations. The scandalous abuse of the rules has turned the CD from a busy and successful negotiation tool into a paralyzed and incapable apparatus.

The long period of inactivity has caused increasing criticism. Capitals have downsized their staff, and impatient delegations are considering taking the FM(C)T negotiations out the CD to other fora. This idea is gaining more and more supporters among those who perceive an FM(C)T as their genuine security interest. They can imagine starting on an FM(C)T with some delegations initially abstaining, like it was with the NPT. Meyer has listed several alternatives: Stay the course in the CD, negotiate among NPT members, negotiate under the auspices of the International Atomic Energy Agency (IAEA), let the five

13 Meyer 2009; Acheson 2009.

NWS negotiate among themselves, and finally create a new working group by the UN.[14] There are pros and cons for all variants. Throughout the years, several governments and non-governmental organisations (NGOs) have conducted seminars on the topic in Geneva, which were mostly attended by many delegates who took the opportunity for discussion. In 2011, the CD conducted "experts side-events", in which the substance is being discussed but not "negotiated". China and Pakistan abstained from these meetings, however.

1.2 The origin: Negative lessons learned from the CTBT negotiations

In the mid-nineties, the similarities of the CTBT and the FM(C)T raised the expectation that the negotiations of both treaties would follow similar patterns. They can be compared in many aspects:[15] Both are major nuclear disarmament symbols, qualitative or quantitative, respectively; both are explicit commitments by the NPT members, laid down in the Principles and Objectives of NPT Review Conferences; both have a nonproliferation component; and both were triggered by new realities after the end of the Cold War, notably the end of U.S. and Russian testing and the lack of need for new fissile material for nuclear weapons. Therefore, many interests and conflicts apply similarly to both.

But the negotiations on the CTBT took only two years until a draft of a treaty text was accomplished, without being interrupted by a stalemate, while the negotiations of the FM(C)T have not even begun since 1996. How can this difference be explained? The working procedures and the structure of the CD are still the same. The membership has grown, but most protagonists of the processes that result in the stalemates were already members during the CTBT negotiations.

The key are some lessons that delegations have learned during the CTBT negotiations. The first stalemate arose after the CTBT negotiations, with its EIF clause that attempts to draw in states against their will.

Thus, the major difference between the two treaties is that lessons have been learned from the CTBT negotiations that strongly influence diplomatic behaviour concerning the FM(C)T negotiations. The CTBT negotiations, in contrast, benefited from a very different lesson, namely the successful negotiation of the Chemical Weapons Convention that the CD had accomplished before. The lessons from the CTBT negotiations are different and the major reason for the deadlock we face today. They are illustrated in the remainder of this section.

At the start of the CTBT negotiations, an underlying conflict could already be seen, but it was not taken very seriously. It can be summarized as nuclear disarmament versus nuclear nonproliferation, although the majority of the negotiation partners wanted both and did not see a contradiction. The NWS were mainly motivated by the prospect of nonproliferation, e.g. the curbing of any future nuclear weapon developments by the states

14 Meyer 2007; Caughley 2011.

15 Keller 1997; Schaper 1997.

outside the NPT, including the development of thermonuclear designs in the cases of India, Israel, and Pakistan. At the same time, they were interested in minimizing their own restrictions as much as possible.[16]

India, a major target of the efforts by the NWS, had the perspective that the NWS demanded far more from the threshold states than they were willing to give in return. Throughout the negotiations, it stressed the disarmament component, in a manner that during the two and a half years became more and more radical. It culminated in the demand for a timetable for comprehensive nuclear disarmament. This goes far beyond any traditional perception of what constitutes a test ban, and was unacceptable to the other participants, mainly because it was unacceptable for the NWS, and everybody knew that insisting would deadlock the negotiations.[17] It is conceivable that India was not interested in successfully finishing this round of negotiations and tried to put the blame on others. Domestically, pressure was exerted to undertake some nuclear tests, thus demonstrating that it is a nuclear weapon state.[18] A test was indeed conducted a few years later and revealed the demand for comprehensive disarmament as truly hypocritical.

But the NWS similarly made the mistake of not granting a single concession to India. An example is that they arrogantly rejected even a simple and reasonable preamble language, suggested by India, which stated that the goal of the treaty is the end of the qualitative arms race.[19] Therefore, any face-saving compromise had become virtually impossible in view of the strong domestic backing of India's extreme position and India's final declaration was logical: It stated that it was not in a position to sign or even ratify a treaty which had been entirely dictated to it and reflected none of its demands. This mistake is all the more difficult to comprehend because a concession would have robbed India of an important argument. Its adopted role of disarmer would have appeared less credible, and if it would still have resisted to accept compromises, it would have had a hard time to justify this position. If one takes the view that concessions would have had no purpose because India would not have signed anyway, it is illogical on the other hand to believe that India could have been forced to sign by international pressure.

The FM(C)T is similarly characterized by a conflict labelled nuclear disarmament versus nuclear nonproliferation, visible since the struggle over the Shannon Mandate. Initially, in 1996, the most visible protagonist of the first stalemate was India, its exaggerated demand, but also the bad way it had been treated. Many delegations learned the lesson that on the one hand they might expect tricks that draw them into positions that they reject and so they have become more suspicious. On the other hand, they learned the

16 It must be emphasized, however, that the scope of the CTBT turned out to be more rigourous than observers had realisticly expected, caused by events that were triggered by the timely coincidence of negotiations on scope and the international pressure on France because of its resumption of nuclear testing. The CTBT in fact is now a good tool for curbing the qualitative arms race. See Schaper 1997.

17 Bidway/Vanaik 1997.

18 See for example: Brahmah Chellaney, If pushed over Test Ban Pact, India could really 'Go Nuclear', IHT, 7-8 September 1996.

19 Johnsohn, Comprehensive Test Ban Treaty: The Endgame, Acronym No 9, April 1996.

lesson that there is a tool to exert pressure, namely blocking consensus and thus any progress in the CD.

During the CTBT negotiations, the disagreement about what weighs more, nuclear disarmament or nonproliferation, popped up only at the end of the negotiations, when the CD dealt with the EIF. This time, however, many delegations are already suspicious of tricks, and the stalemate has arisen before the negotiations have started. Instead of being open to contradicting positions, Pakistan insists on a formulation that reflects the outcome of the negotiations it desires.

In sum, the lessons of the CTBT negotiations have caused the current stalemate, they have taught delegations to abuse the rules of procedures of the CD. They have also weakened the perception that a treaty might be beneficial for all participants, instead, many delegations now believe that there will be winners and losers, and they perceive the two components nuclear disarmament and nonproliferation as a contradiction instead of a mutual reinforcement.

2. Why an FM(C)T is important – four benefits

The FM(C)T will have many benefits, and many states have a strong interest in it. But the emphasis that they place on the different benefits of the treaty varies, and fatally, some states regard them as contradictory instead of as reinforcing. As a result, there are different positions on scope and verification. Each delegation will try to push its priorities, for example in language on the preamble, on scope, on verification, or on EIF, as happened in case of the CTBT. If the states do not take care to view the various benefits as mutually reinforcing, an FM(C)T is unlikely to ever materialize. In the following, four advantages of the treaty will be presented.

2.1 Irreversibility of nuclear disarmament and implementation of Article VI of the NPT

The uncontested minimum goal of an FM(C)T is a ban on future production of fissile material for explosive purposes. This means that the quantities can only be reduced, but not increased which is at least a theoretical symbol of an end to the arms race.

Both, the FM(C)T and the CTBT have been labelled as "nuclear disarmament measures" in terms of article VI of the NPT and have been included in the list of Principles and Objectives for Nuclear Non-proliferation and Disarmament at the NPT Review and Extension Conference 1995. Successful FM(C)T negotiations therefore would strengthen the NPT.

Critics maintain that just a cutoff is not enough, since large quantities of fissile material are excess. They are owned by the nuclear-weapon states and exceed the quantities needed for a potential rearmament up to numbers of the peak of the Cold War (see appendix I for a quantitative overview). Therefore, they claim, it is necessary to reduce the existing quantities. Only then would a treaty have the effect of nuclear disarmament. This view is rejected by several delegations. The proponents are still the same as during the negotiations of the Shannon Mandate, when this conflict also played a central role, as described above. It plays a role in the deadlock of the CD, and similarly it will play a central role in the negotiations on scope. Pakistan is at the forefront of those who demand an inclusion of previously fabricated fissile material, while the nuclear weapon states are opposed.

2.2 Reducing the discrimination of the NPT

The UNGA resolution and the principles and objectives refer to the *principle of nondiscrimination* of an FM(C)T. Unlike the NPT, an FM(C)T would not discriminate between nuclear- and non-nuclear weapon states. Rights and duties would be the same for all parties. Furthermore, it is unlikely that it will impose any duties for non-nuclear-weapon states that go beyond those of the NPT. Non-nuclear-weapon states are already verifiably not producing fissile material for explosive purposes. Therefore, an FM(C)T would mean additional duties for the nuclear-weapon states but not for the non-nuclear-weapon states, thus it would result in a reduction of the discrimination in the non-proliferation regime. The nuclear industry in the non-nuclear-weapon states sometimes claims that it perceives a disadvantage in comparison to their competitors in the nuclear-weapon states. Whether this claim is true or not, an FM(C)T will insert some duties for the nuclear industry in the nuclear-weapon states and will appease such complaints.

Nevertheless, discrimination in the nonproliferation regime as a whole will not be totally eliminated, because the FM(C)T will not be a "Global Zero" treaty, e.g. a treaty for a world without nuclear weapons. Some disarmament advocates criticize this. They maintain that an FM(C)T would serve only as an alibi, because the NWS would still be allowed large quantities of fissile material for weapons, while the NNWS would not, at least as long as the duties for the NWS would be minor. Indeed, there are constituencies in the nuclear-weapon states that have no interest in reducing the discrimination.

2.3 Drawing in states outside the NPT

A benefit of a treaty would be its potential to draw in those states outside the NPT – India, Pakistan, Israel and North Korea. For some states, this is the major motivation, because they want to cap the number of warheads in these states. Similarly, drawing them in was the motivation of some states during the CTBT negotiations, for some delegations by far the most important one, but not so for others. This led to the conflict on EIF of the CTBT. A repetition of this conflict must not be allowed this time. This means that a FM(C)T must offer enough incentives for states outside the NPT, and all states should accept that in an initial phase some delegations might still abstain. Today, it seems that the number of states who insist that all NWS, states outside the CD, and all users of nuclear energy must be part of it, is shrinking.

2.4 Reducing the risk of nuclear terrorism and promoting a culture of "international responsibility"

In non-nuclear-weapon states, the nuclear industry has responsibilities to the IAEA. Material accountancy is precise so that it can be presented to the IAEA at any time. The technical equipment for safeguards and security is installed in all plants, and international duties promote a culture of responsibility and transparency. In contrast, in some nuclear-weapon states and states outside the NPT, the nuclear industry is perceived as a matter of purely national concern. Verification of an FM(C)T would introduce standards of accountancy and adequate discipline, and would replace the notion of "national concern" with the notion of "international responsibility". This would change the nuclear culture, cause more discipline in accountancy, and in turn could lessen the risks of illegal diversion. Not surprisingly, this argument holds especially in NNWS with nuclear industry, but not in NWS. They claim that their security is sufficient and that they do not need the international community to improve their own discipline.

3. Definitions and categorization of fissile material

In order to negotiate on formulations of a treaty text, especially on its scope and on provisions for verification, it is useful to have a common language by using agreed definitions. Both the terms "fissile material" and "production" have ambiguous meanings because they cover a range of different options. Consequently, it is useful to have a range of terms to allow for clarity in language on scope and on verification.

3.1 Technical categorization of fissile material according to IAEA definitions

Although the term "fissile material" is defined in physics, it is not in arms control.[20] In the context of an FM(C)T, the term "fissile" is commonly understood as all materials that can be used for the fabrication of explosives, namely HEU, U-233, and plutonium, but also neptunium and eventually americium and others. Indeed, a helpful categorization of fissile material is their usefulness for nuclear explosives.

The IAEA has undertaken to give a legal meaning to technical substance and has defined several technical terms for use in legal documents on safeguards regulations. These definitions have become standards and eventually can be refined in case of new insights. Depending on the technical hurdles on the way to an explosive, these categories are *unirradiated or irradiated direct use material*, *indirect use material, special fissionable material*, simply *nuclear material* and *other material*.[21]

The definitions have been used by scientists and safeguards practitioners for decades. Whether or not FM(C)T verification will be similar to NPT verification, it will at least

20 In physics, only those isotopes are called "fissile" that can be fissioned with thermal neutrons.

21 The text of the definitions is in the IAEA Safeguards Glossary, 2001.

draw from these experiences. In order to be clear about what is similar and what is different, it is highly recommendable to define technical terms in the context of scope and verification provisions by using this language. Nevertheless, as the IAEA safeguards cover only civilian materials, in supplement to this technical categorization, a categorization in terms of use of material will also be needed, which is discussed in the next section.

Appendix II gives an overview on nuclear materials and isotopes, their role in the development of an explosive, and their IAEA categorization.

3.2 Political categorization of fissile material

While the technical terms are very useful in shaping language on verification, they are not sufficient for the formulation of the scope of an FM(C)T. The scope must differentiate between various uses of fissile material. Therefore, in this section, I propose another categorization. Fissile material can be characterized according to their use and status, e.g., under international safeguards; for civilian use; declared excess; excess to explosive needs; or designated for other military needs such as naval fuel, in the warheads fabrication line, or in warheads.

3.2.1 Fissile material under safeguards

Materials with nuclear explosive capabilities can principally also be used in the civilian nuclear fuel cycle or for military purposes other than explosives, e.g. naval fuel. In non-nuclear weapons states, under an FM(C)T, and in a future nuclear weapons free world, it must be assured that any attempt to use nuclear materials for other than civilian and declared purposes would have a high probability of being detected at an early time. The means to this end are international safeguards. Therefore, "disarmament of fissile material for weapons" is synonymous with "submitting fissile material to appropriate international safeguards."

A provision that fissile material, once under safeguards, may never again be withdrawn creates a political *irreversibility* of disarmament. An FM(C)T without such provision would not be credible.

Since there is a wide variation of policies concerning civilian nuclear energy in various countries, it must be assumed that nuclear disarmament and arms control should be pursued independently from civilian energy policies and that the use of civilian separated plutonium and reprocessing will also be possible with an FM(C)T.[22] "Disarmament of plutonium" therefore does not mean elimination of plutonium, but it means elimination of unsafeguarded plutonium.

Similarly, "disarmament of HEU" should be defined as submitting HEU to international safeguards. This action is accomplished much faster than the technical disarma-

22 There are considerations of new fuel cycles that are more proliferation resistant. As an example, when a fuel cycle does not include separated direct use material, it is more proliferation resistant than a fuel cycle involving reprocessing.

ment measures. Nevertheless, there are several differences between plutonium and HEU: Firstly, while the civilian use of plutonium takes place on a large scale, the civilian use of HEU does not. The only civilian use for HEU is as fuel for a small number of research reactors. Most research reactors are fuelled with LEU, and in recent years, the international community is working to convert all research reactors from HEU to LEU. It is already a policy goal to phase out the use of HEU in research reactors altogether. This is likely to happen once any remaining unconverted research reactors reach the end of their design life. Another use is in military naval propulsion. Secondly, HEU is the most proliferation-prone direct use material, as it is easier to handle than plutonium because of its lower radioactivity and fewer technical problems with metal machining. Thirdly, what makes things worse, detection methods for smuggled uranium are more difficult. Therefore, it is also easier to smuggle and hide HEU than plutonium.

The differences should lead to the – longer term – goal of an elimination of any HEU production altogether. Whether this should already be specified in an FM(C)T is a question to consider. Some delegations might believe that this is likely to overburden the negotiations. For the more ambitious and longer term goal of the verification of a nuclear weapons free world, it would be easier, if the production and possession of military and civilian HEU was completely banned and all HEU would be technically disarmed. Politically, HEU under safeguards should be regarded as disarmed HEU.

France and Britain are the only nuclear weapons states whose entire civilian nuclear fuel cycles are subject to safeguards by Euratom, though not by the IAEA. Euratom safeguards are at least as intrusive and detailed as those of the IAEA. All NWS can submit fissile material and facilities to IAEA safeguards, but they are also free to withdraw them from such safeguards, according to their Voluntary Offer Agreement with the Agency, in contrast to non-nuclear-weapon states whose fissile material are safeguarded without exception. To date, IAEA safeguarding in NWS has taken place only to a very limited extent. The U.S. and the UK have submitted a few tons of formerly military HEU and plutonium to safeguards; the other NWS have submitted nothing (see Appendix I).

3.2.2 Civilian fissile material and fissile material declared excess to defense needs but not yet under safeguards

After the end of the Cold War, the U.S. and Russia declared large quantities of plutonium and HEU excess to nuclear weapons needs. Most of this material is from dismantled nuclear weapons or from the nuclear weapons fabrication pipelines, and their possessors intend either to use it in the civilian nuclear industry or to dispose of it. However, this material has not yet been submitted to international safeguards. Other nuclear weapon states have not even any declared excess material.

For economic and technical reasons, it will take decades until the disposition programmes will be completed, and the timetable and means are only partly clear. In the meantime, the materials must be stored, where they remain at risk for rearmament and proliferation. An important disarmament step would be to irreversibly submit this material to international safeguards.

So far, there has been no visible attempt to place international safeguards on excess materials. A variety of informal U.S.-Russian transparency commitments were undertaken in the 1990s, but have never been fulfilled.[23] On the contrary, in discussions on FM(C)T, diplomats of NWS up to now have categorically refused to consider any obligations whatsoever on existing fissile material. One obstacle which is frequently cited as an argument against safeguards and even against some transparency measures must be examined in detail: The owners claim that their excess fissile material are in physical forms that reveal too much sensitive information. This information must first be removed or adequately protected before these countries would consider the imposition of any international safeguards. This is being done either by technical changes to the material, or by special managed access procedures.[24] Progress on this problem is the prerequisite for progress in promoting universal safeguards.[25]

3.2.3 Fissile material considered excess to defence needs but not declared so

In addition to the materials the nuclear weapon states have declared, they possess even more fissile material they probably consider excess but have not declared as such. Considering the reductions of the nuclear arsenals after the end of the Cold War, hundreds of tons of weapons-usable materials seem to have become excess at least to explosive needs, sufficient for many thousands of warheads. Some of the HEU is allocated to future use in naval fuel, but there are also considerable quantities of plutonium that could be either directly disposed of or used in civilian industry.

Declaration of excess quantities and international transparency of all fissile material holdings including military use materials is a prerequisite for safeguards.

The quantities in the category “excess but not declared so” are larger than the quantities of declared materials. The U.S. reserves large amounts for future use in naval reactors (see Appendix I). They constitute an additional reserve for potential rearmament. It would be desirable that owners increase the amount of declared quantities.

3.2.4 Naval fuel

Only a few countries use HEU for military naval reactors, namely the U.S. and Britain. Others use LEU or HEU that is enriched far below 90%. A lot of progress has been made on the development of new fuels that allow the conversion of civilian research reactors using HEU to LEU without loss of performance. Similar fuels could also be used in new reactor designs. But naval reactors using HEU have been designed decades ago, and no attempt to consider the new fuels for a new reactor design has become known up to today.

There are abundant quantities of HEU from disarmament, namely from the category “excess but not declared so”. They are sufficient to fuel the naval reactors for many decades to come, and any necessity to produce fresh HEU for naval reactors will arise only in

23 Bunn, M. 2000: p. 47.

24 Examples of possible procedures are illustrated in Bukharin 2003.

25 Schaper 2004.

the far future. It may be expected that until then new naval reactors will be designed that make use of the new fuels, and that this way they allow the use of LEU instead of HEU. Thus, a universal ban on HEU production will become a more realistic prospect. More countries might use naval reactors in the future, not only for military but also for civilian applications such as icebreakers. This should trigger efforts to develop reactor designs that use modern LEU fuels.

3.2.5 Fissile material in use for nuclear explosives

As long as there are still nuclear weapons, there is fissile material for explosive use. Such material can be in weapons, warhead components, reservoirs, or in production pipelines. If there is a commitment to nuclear disarmament, the warheads will be dismantled and more of this material will become excess, entering one of the other categories of fissile material described above. An FM(C)T must take into account that there are states that will further possess fissile material for explosive use.

The two kinds of categorization presented in this paper – technical categorization in terms of IAEA definitions and political categorization in terms of usage – can be used jointly in order to define “fissile material” in the treaty and to phrase treaty language on scope and verification.

3.3 What does “production” mean?

The Shannon mandate contains another term that may be contested during the negotiations and that needs to be discussed, namely the “production” of fissile material. This term is simple only at first glance. It can be understood in various ways, and this may eventually have implications for the scope of the treaty.

In a narrow understanding, “production” would mean only enrichment of uranium to HEU and the separation of plutonium, namely running facilities in a way that their output is unirradiated direct-use material. In case of uranium, the manufacturing of LEU up to 19.9% would not classify as “production”, nor would the irradiation of fuel in reactors that yields spent fuel which contains plutonium, which according to the IAEA definition is “irradiated direct-use material”. As indeed only direct-use material can be used for nuclear weapons without any further technical processing, this definition may be considered sufficient. However, it must be kept in mind that the technical effort to produce HEU from 19.9% LEU by further enrichment is rather low for a possessor of enrichment technology, and the time needed is comparatively short. Similarly, spent fuel contains large quantities of plutonium, and its separation, e.g. the production of unirradiated from irradiated direct-use material might happen in a fairly short time.

In a broader understanding, the term “production” could include the irradiation of fuel in reactors, e.g. the fabrication of irradiated dual-use material.

Nevertheless, even if the term would be defined in the narrow sense, and the scope would be defined accordingly, this does not automatically preclude a verification that is thorough by including material accountancy of the U-235 inventory in enrichment plants and of the plutonium inventory in reactors.

Key for confidence in treaty compliance is verification. Therefore, it is not necessary to define the term “production”. The power that the treaty can develop is independent from the existence of a definition of the term “production”, but it depends a lot on the thoroughness of verification.

4. Variations of scope

In the preceding section, we have looked at various types of fissile material. But at the center of discussions on the scope lies a disagreement – whether a treaty should cover only future production or whether it should also include existing materials produced prior to EIF. During the negotiations of the Shannon Mandate, several states called for the inclusion of materials produced prior to EIF. It was the consensus, however, that production for civilian nuclear industry should not be banned.

Mostly, calls for an inclusion of already existing materials into an FM(C)T are rather vague. There are many variations of possible regulations for material produced prior to EIF and the scope of an FM(C)T. In the following, some of these are illustrated. They can be allocated to changes of inventories of the above listed political categories of fissile material. They are not mutually exclusive and their elements could be subject to the negotiations.

4.1 No regulations at all on existing materials

One extreme in the debates is the view that a treaty should deal only with materials produced after EIF. This is equivalent to the view that, in the future, the nuclear-weapon states and the states outside the NPT will deal with their stocks produced prior to EIF at their pleasure, for example their civilian, excess and military materials, without need to justify their actions to the international community. Theoretically, they could use these stocks for future re-armament beyond the maximum of the Cold War. This would be a contradiction to the *Global Zero* vision that U.S. President Barak Obama invoked at his famous speech in Prague in 2009, which has been applauded by many states.[26] Disappointment and criticism at future NPT Review Conferences would be almost unavoidable. NNWS would complain that the treaty would be merely an instrument of nonproliferation, instead of an advancement of nuclear disarmament.

The most narrow variant of scope would be simply the “ban of the production of direct-use material after EIF”, “production” defined in the narrow sense explained above (section 3.3). But even such an FMCT (“C” not in brackets) would offer some disarmament potential, which must be kept in mind: The mere fact that an international verifica-

26 The White House, Office of the Press Secretary, Remarks by President Barack Obama, April 5, 2009, www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered/ (2.7.2009).

tion authority has rights in a NWS is a paradigm shift, namely the deviation from the attitude of "exclusively national concern". The more thorough the verification, the better the ground will be prepared for future nuclear disarmament. However, it is unlikely that all delegations will accept such a modest scope.

4.2 Comprehensive disarmament

The other extreme of scope would be a ban of all fissile material for explosive use including that produced in the past. This would be equivalent to a treaty for comprehensive disarmament. In this case, a treaty would set a timetable according to which the use of fissile material for nuclear weapons would be phased out, and this would be verified. Warheads would be dismantled and their fissile material subjected to safeguards. It is unlikely that any delegation believes that, for the time being, this scenario would be acceptable to all delegations in the Conference on Disarmament, as, similarly, many states during the CTBT negotiations did not accept India's demand for a time-bound framework for comprehensive nuclear disarmament. In terms of the above-illustrated political categories for fissile material, this variant of scope would mean moving all fissile material into the category of "fissile material under safeguards".

4.3 Irreversibility by a ban on re-designation to explosive needs

Between these two extremes, there are many variants. A minimum demand would be irreversibility, a view that is shared by many. This means to create a one-way road for disarmament. Firstly, nuclear material that is declared as "excess" or "civilian" must verifiably never be reused for explosive purposes, even if it was produced prior to EIF. Secondly, material that has been submitted to safeguards must never be withdrawn. "Once civilian, forever civilian; once under safeguards, forever under safeguards." These are demands that are easy to comply with.

In the past, only few IAEA safeguards have been installed in nuclear-weapon states. As mentioned, the United Kingdom and the United States are the only states that have submitted excess plutonium to IAEA safeguards. The quantities are just a few tons, although the quantities of excess material are much higher. These are examples of safeguards that must become irreversible. In terms of the above-illustrated political categories for fissile material, this variant of scope means that the quantities in the category of "fissile material in use for nuclear explosives" can only be reduced, and the quantities in the category of "fissile material under safeguards" can only be increased. It is unlikely that any state would strongly oppose such provision. In addition, an FM(C)T could contain a commitment to increase the quantities of fissile material under safeguards. This variant also seems to be shared by many, however the NWS are unlikely to accept a time table.

4.4 Declarations of excess fissile material

Declarations and transparency of data on fissile material are the first prerequisite of international safeguards and are a goal of diplomacy anyway. The call for more transparency of stocks is not new, and so it is clear that it will play a role during the negotiations.

A variant of an FM(C)T scope could be some obligations towards more transparency on fissile material, more precisely, an obligation to increase the quantities of declared excess materials. However, some NWS delegations might claim that they don't have undeclared excess materials, which might or might not be plausible. Quantities of undeclared excess fissile material can be estimated from dismantled nuclear weapons, but the quantity inside a warhead is classified. Therefore, estimates by NGOs are imprecise. Some NWS might want to retain the option of future rearmament, and although they do not see the need for additional production, they want to keep a reserve. The U.S. wants to retain some of the HEU from dismantled warheads for fuel in naval reactors.

Nevertheless, more transparency of fissile material, as well as transparency on warhead numbers, is on the nuclear disarmament agenda. It is a prerequisite for various technical and political disarmament projects. Whether this should be part of an FM(C)T or of any parallel or future endeavours, is another question. However, some qualitative commitments to more transparency of stocks would at least show some general good will.

Those states that call for the inclusion of previously fabricated material should be among the first to provide information on their own stocks. A promising example is the publication by the United States of its plutonium production and use from 1944 through 1994 in February 1996.[27] In 2001, the United States also published its HEU production and use from 1945 to 1996.[28] In 2000, the United Kingdom published information on its plutonium production.[29]

There are various reasons why many NWS resist greater transparency of their stocks. It is recommended that they pursue a detailed analysis of their secrecy regulations and decide whether some information that would be useful for transparency and verification could be revealed. A prominent example of such an endeavour is the *Openness Initiative* that the United States undertook in the mid-1990s and that led to the efforts to create transparency of the plutonium and HEU production.[30]

27 United States Department of Energy, National Nuclear Security Administration, Plutonium: The First 50 Years: United States Plutonium Production, Acquisition, and Utilization from 1944 through 1994, 1996.

28 United States Department of Energy, National Nuclear Security Administration, Highly Enriched Uranium: Striking A Balance. A Historical Report on the United States Highly Enriched Uranium Production, Acquisition, and Utilization Activities from 1945 through September 30, 1996, January 2001, publicly released 2006.

29 Ministry of Defence, Historical Accounting for UK Defence Highly Enriched Uranium, A report by the Ministry of Defence on the role of historical accounting for Highly Enriched Uranium for the United Kingdom's Defence Nuclear programmes, March 2006.

30 Draft Public Guidelines to Department of Energy Classification of Information, US Department of Energy, 27 June 1994, www.fas.org/irp/doddir/doe/pubg.html (13.12.2011).

4.5 A ban on production of HEU for submarines and naval vessels

The United States has reserved more than 100 t of HEU for naval fuel. In discussions since 1996, the call had been heard that the FM(C)T should allow the production of HEU for this purpose. But this would create a severe loophole:

The HEU and the submarines are kept extremely secret. Should this secrecy be maintained, it would not be possible to verify that the HEU is indeed used as fuel. Even if most of the secrecy would be lifted and safeguards be enabled, the question must be asked why submarine reactors cannot be converted to less enriched fuel like research reactors, or why it is not possible to design new LEU reactors. Until this is accomplished, the huge stock of HEU reserved for submarines can be consumed. Any new production would only be necessary in the far future.

Furthermore, banning the production of HEU for naval fuel purposes would open the door to banning the production of HEU for any purpose and thereby eliminating HEU from the earth on the long term.

5. Verification

Just as there are many variations of scope, there are also many verification scenarios, extending from just a fence around former military reprocessing and enrichment facilities to intrusive global concepts. Even if the scope is defined in the narrowest way, e.g. only a ban on future production of direct use material, verification must still ensure that material produced later is not simply declared as earlier production. Otherwise it would not be credible. All material produced after EIF should only enter the one category of safeguarded material.

5.1 Credibility and non-discrimination

In order to ensure *credibility*, verification thus must not only cover non-production but also non-diversion. This is the same as what is already being verified in NNWS under full scope safeguards. The difference is the “black box” of non-safeguarded fissile material produced prior to EIF, that the NWS will eventually be allowed.

In a working paper of 1994, the IAEA assesses the requirements for a credible verification of an FMCT as follows:[31]

> “From the technical perspective, applying verification arrangements to anything less than a State's entire fuel cycle could not give the same level of assurance of non-production of fissile material for nuclear weapons purposes or for use in other nuclear explosive devices as it is provided by the IAEA by implementing comprehensive safeguards agreements in NNWS.”

31 IAEA 1994.

However, discussions since 1996 reveal that some negotiating partners will not accept such a comprehensive system. They are the nuclear weapon states but also some NNWS, namely Australia. Although in the long term, the goal should be to establish the same safeguards system for the civilian fuel cycles universally, they want to consider whether some requirements could be reduced to a certain extent for the FM(C)T.

Another principle has also been stated in the Shannon mandate: The treaty is intended to be *non-discriminatory*. This means that all rights and obligations regarding verification should apply equally to all member states. The measures to verify this ban should therefore be the same for everybody. NNWS are already subject to a similar obligation and corresponding verification by the IAEA, defined by INFCIRC/153 and INFCIRC/540. During the FM(C)T negotiations, two general questions on verification will arise: Firstly, whether the verification obligations of the NNWS are already met by the NPT verification, and secondly, how close the two verification systems will come. The verification tasks for both treaties are very similar and large differences in the verification systems would be interpreted as discrimination. Differences in the verification systems of both treaties should therefore stem only from differences in scope between the NPT and the FM(C)T.

There are two such differences: The first is the unsafeguarded fissile material produced prior to EIF in NWS (being in other material categories than the safeguarded one). It might or might not be subject to special regulations. The second is the different histories of the nuclear complexes in the NWS and the NNWS. The latter have been subject to international safeguards for a long time, and therefore have been adapted to precise material accountancy. This is not the case for the nuclear complexes in NWS that therefore carry a heritage of imprecision in material accountancy. The continued existence of fissile material not under safeguards in NWS and the lacking tradition of international safeguards cause special problems for verification that have to be coped with, yet have to be accepted for a certain time period.

In the discussions on the verification of an FM(C)T, however, other arguments have been raised: Firstly, it is claimed that the verification would become too expensive if it would be as thorough as in NNWS and would cover all civilian nuclear industry. Secondly, it is argued, regarding the large number of warheads the NWS possess, one illegal warhead more or less does not make much of a difference, in contrast to a NNWS where one or zero warheads make a big difference and therefore implies a higher precision of verification.

The first argument must be taken seriously, even though it lacks substantiation. The only basis for cost estimates is the above-quoted IAEA study of 1994.[32] According to this study, which considers the world's nuclear industry of 1993, the IAEA budget for safeguards would have to be roughly tripled in case of universal full scope safeguards. But even in case of different verification standards, the budget must also be increased, to a somewhat lower percentage, but the cost difference between both scenarios does not seem to make a big difference. Judgements on costs are determined by priorities. As an example, the U.S. has allocated billions of dollars for the maintenance of the Nevada test site in

32 IAEA 1994.

the context of negotiating and signing the CTBT, which is more than one order of magnitude more than the international community would annually spend on universal full scope safeguards. Apparently some consider this investment much more important than investments in international safeguards. In order to assist future discussions, the IAEA should be tasked to conduct an updated costs study.

The second argument needs some more fundamental considerations. Positions depend on the perspective whether an FM(C)T will be a precursor for a world without nuclear weapons or not. As long as warhead numbers are large, small deviations do not matter much. But when numbers become very small, this will make a huge difference. Only when the vision of a nuclear weapon free world is lacking, it may be claimed that there should be a differentiation in thoroughness of safeguards between NWS and NNWS. It is a fundamental question whether there can be differences in treaty compliance: It is a matter of great concern if a NNWS breaches an FM(C)T (or the NPT), but is it less of a concern if a NWS does? Does the obligation to comply with a treaty not hold equally for all members? Or, in safeguards terminology: Which assurance must be created to have confidence in a member state? Can there be different levels of assurance for different members?

In fact, many decision makers in NWS have not yet accustomed themselves to the thought of being subjected to similar verification intrusiveness as NNWS. Pride and status still play an important role. The FM(C)T has the potential to change this situation with a verification regime for NWS, and this is one of the benefits of the treaty.

But it is not only pride and status that have a detrimental effect on the motivation of the NWS for more international control, they also fear that they might get into trouble because of their incomplete material accountancy in the past. This is understandable. It must be ensured that there is a solution to this problem that allows the NWS to save face and avoids any criticism because of past inaccuracy. Therefore it is highly important that all member states understand this problem and develop patience instead of discouraging states by overburdening them with unrealizable demands. For example, the U.S. publication of its plutonium and HEU production must be praised as an important progress. As a side effect, the publications reveal that the material unaccounted for, e. g. the difference between measured and book numbers, is still rather large. It would be sufficient for several dozens of warheads, due to the past when bookkeeping was not deemed as important as today. But it would be a severe mistake to criticize this fact, as has occasionally happened. Instead the U.S. publication should be applauded as an encouragement for others.

To summarize: The vision should be a universal safeguards system for all civilian fissile material without further discrimination. However, it is clear that there are still difficulties to be overcome. They should be viewed with both patience and eagerness for cooperation towards a common goal.

5.2 Applying IAEA safeguards

As discussed earlier, "production" in the context of an FM(C)T can have different meanings. Similarly, as the IAEA does not use the term "fissile material", there is no official IAEA definition of the term "production". Instead there is a definition of the term *inven-*

tory change which defines the differences between entry and exit quantities of nuclear material to and from safeguards. There are several ways by which the inventory of the material subject to safeguards can change, including production, but also export and import, loss, or transformation into an unrecoverable state. Since all fissile material produced after EIF will be subject to FM(C)T verification, the "starting point and termination of verification measures" must be fixed in the treaty text.

Also the verification tasks will have to be defined. Under the assumption that the scope covers only production after EIF, the verification tasks will be:

- Provide assurance that shut-down production facilities remain shut-down.
- Provide assurance that material produced at declared facilities is not diverted to purposes unknown.
- Provide assurance that no undeclared production takes place.
- Provide assurance that no material is diverted from inventories of material produced after EIF.
- Provide assurance that no undeclared production facilities exist.

Therefore, it must be defined which levels of assurance will be considered satisfactory. Such definitions should be expressed as probabilities for detecting violations. The probability should be the higher the more sensitive the diversion is, e.g. LEU is less sensitive than HEU. For this purpose, the IAEA defines so-called significant quantities and timeliness goals. During the negotiations, it must be decided whether similar or other quantities of fissile material are considered significant to be detected, and which time interval between production and detection should be chosen. In INFCIRC/153 type safeguards, a lot of regular and frequent routine inspections take place in order to meet the timeliness goals. It might be considered whether alternatively, more random and less routine inspections should be envisaged. This would provide the same degree of assurance but would be less costly.

In case the treaty will envision the reduction of fissile material, methods are the same as planned for the application of safeguards to excess fissile material. So far, they are planned "as soon as practicable", but not yet applied, mainly because of secrecy problems.[33]

5.3 Three examples for verification scenarios

5.3.1 First scenario – the focused approach: verification only of facilities whose output is unirradiated direct-use material

As an example of a minimalist scenario, only facilities capable of reprocessing and enrichment, e.g. those that produce unirradiated direct-use material, would be subject to verification. This approach has become known by the name *focused approach* and has

33 See Shea 1993a and Shea 2010.

been promoted by Australia for years.[34] It is also favoured by the U.S. and other NWS.[35] Their major arguments are the costs.

The facilities to be monitored can be former military reprocessing and enrichment plants, civilian commercial plants, pilot plants, and research installations such as hot cells. The output of HEU enrichment plants would be subject to verification. Verification of LEU enrichment plants would be limited to design verification which means creating assurance that they are not configured to produce HEU. The separated direct-use materials produced at these plants must then be followed downstream until the defined termination of verification measures. As a consequence, all facilities that store, process or use them after EIF must be included. Facilities that process HEU, plutonium, or U-233 are fuel fabrication and conversion plants, e.g. for MOX or research reactor fuel that contains HEU, or plants that are used in case some of this material is disposed of in another form.

Plants that use the material are mainly nuclear reactors. In a minimum approach, the verification would end upon irradiation of the material, in which case it must be determined at which level of irradiation, e.g. at which burn-up, the verification would cease. A disadvantage of such a minimalist approach would be that in such spent fuel there will still be large fractions of plutonium or HEU which can be recovered by reprocessing.

At the center of INFCIRC/153 type safeguards lies a comprehensive material accountancy. The proponents of the focused approach reject this method, thus the credibility of the FM(C)T would be unsatisfactory.

5.3.2 Second scenario: Verification of all facilities whose output is any direct-use material

An example of a more thorough verification regime is one that would cover not only reprocessing and HEU enrichment plants but also nuclear reactors, and it would include not only separated but also irradiated direct-use material produced after EIF. This way, accountancy of the inventory of a plant would be possible, and a detection probability of missing isotopes would be established. The verification therefore would be able to detect clandestine production of irradiated direct-use material, e.g. spent fuel from reactors. The materials must be followed downstream until the termination point of verification.

In order to enhance the probability that diversion is detected, this termination point should be the moment when the material is practically irrecoverable, similarly as in NPT full-scope safeguards (INFCIRC/153: § 11), yet, the Agency is still provided with information (INFCIRC/540: § 2 (xiii)). As a consequence, not only nuclear reactors but also storage sites, fuel conditioning and the input into reprocessing plants must be verified. Spent fuel produced after EIF should be included into the material accountancy. Otherwise, an intransparent reservoir could be created, and the verification regime would not be credible.

However, opposition against this proposal has already been voiced and justified by overly high costs. Frequent and regular visits of all light water reactors are indeed very

34 Bragin/Carlsson/Hill, 1998.

35 Goodman 2001.

costly. On-site inspections are the most expensive part of verification. If all reactors in NWS would be inspected with the same frequency as in NNWS, a large part of the budget will be consumed by reactor inspections. Therefore, it should be considered whether a random inspection regime is feasible. Depending on the sensitivity of a reactor, different detection probabilities within a time interval could be assigned, and as consequence, inspections would take place with different frequencies. This would save costs and would still not change the credibility very much.

Several categories of nuclear reactors can be distinguished according to their sensitivity:

1) Reactors that in the past had been dedicated to the production of nuclear weapons and will now be used for civilian purposes,
2) reactors that had been dedicated to the production of nuclear weapons and that are now shut-down,
3) commercially used reactors that so far had not been submitted to safeguards. For them, sub-categories must be determined according to the kind of fuel. As an example, research reactors using HEU might need more attention than ordinary light water reactors as long as the civilian HEU is not phased out. It must also be decided whether there should be a power limit below which reactors are excluded.

There are only about 7 to 10 reactors in the first category. They would require strong verification, e.g. an inspection regime on a regular basis. This would not be very expensive because of the small number of those reactors. The verification that reactors of category 2 are indeed shut-down is inexpensive. Reactors of category 3 could be verified with random inspections. Material accountancy based on reports of all spent fuel produced after EIF should be established by the verification authority and followed downstream until the defined termination point of verification.

5.3.3 Third scenario: Comprehensive verification: including also special fissionable material production

In an even more thorough and credible scenario, verification of LEU production would also be included. The major element would be material accountancy of the LEU produced after EIF. States would declare all inventories produced after EIF. This means that at LEU enrichment facilities, not only design information, but also the complete material balance would be verified. An advantage would be the ability to detect diversion at LEU enrichment plants. The verification would follow the produced materials to storage, fuel fabrication and into reactors. As a consequence, firstly the assurance against undeclared HEU production in a declared enrichment facility would be higher than in the other scenarios, secondly, the verification of the material balances at reactors can be completed because material accountancy will cover not only the output at reactors. Instead, the consistency would be higher as the input would be also known. What is still lacking in comparison to full scope safeguards is a high assurance against the diversion of source material, e.g. natural or depleted uranium, or thorium.

5.4 Special problems of verification

Although a long-term goal of nuclear arms control could be global safeguards with the same standards for everybody, there are several problems that are specific to the world of today in which some NWS possess unsafeguarded materials and installations. Some of the problems are not trivial, and the verification must cope with them, regardless of which verification scenario will be chosen. But why should we bother with special problems now, at a time when the negotiations have not yet begun? The problems are often cited by sceptics who do not believe that verification of an FM(C)T would be feasible. An example is the reasoning of the U.S. during the period from 2004 to 2009, when it opposed verification of an FM(C)T. At that time, U.S. delegates listed these problems in their justifications. This is a reminder of the many years before the CTBT negotiations, when many opponents maintained that a CTBT would not be verifiable. But at that time, a group of scientific experts was implemented that investigated the various technical aspects of verification. When the negotiations finally started, a set of potential verification scenarios was rapidly available.

Similarly, many problems of FM(C)T verification are of a technical nature and could be researched while negotiations do not yet take place. The problems are discussed in the following:

5.4.1 Detection of clandestine production

In any of the above verification approaches, it will be necessary to detect clandestine production. The methods for the detection of clandestine production are national technical means (NTM), including the use of intelligence information, societal verification, environmental sampling, wide area monitoring, and onsite inspections.[36] Since all production requires feed material, reconstruction of past production and full scope material accountancy will also contribute. However, the latter is mainly useful in countries whose total nuclear inventory is accounted for. As long as there are still large stocks of various fissile material unaccounted for, or as long material accountancy in a state is not yet fully established, it is not too powerful. For less developed states, another verification method is observing international trade, which is also currently being used as a NTM method. Also, societal verification plays an important role, even in non-democratic states where leaders never can be certain that there would be no defectors. The various methods form a synergy that creates a high confidence that an illegal activity can be detected. The methods are also applied and further improved for NPT verification.

The weakest point is the early detection of clandestine production of HEU. The detection is easier in cases of states without existing civilian enrichment facilities than in those that run them already. In this case, societal verification and intelligence are crucial to establish initial suspicions of a location where inspections can be conducted. Additionally, a method could be the detection of the feed material for centrifuge plants, e.g. uranium fluoride (UF_6).[37] Nevertheless, the clandestine set-up of a parallel plant always runs the

36 NAS 2005.

37 Kemp 2008.

risk of being detected by societal verification. As soon as a suspicion arises, on-site-inspections are an appropriate tool to create clarity.

Clandestine reprocessing for plutonium production is much easier to detect than enrichment. Reprocessing emits characteristic effluents, including noble gases such as krypton-85 that can hardly be shielded and that can be detected even in small traces at distances of several kilometers. In order to create a risk that clandestine production will be detected, FM(C)T verification will make use of the same methods as NPT verification.

But there is a major difference between NNWS and NWS: The role of inspections in the clarification of suspicions in NWS can be limited at some "special locations". They are facilities that contain nuclear weapon-related secrets, namely weapons maintenance, dismantlement, and remanufacturing facilities in which processes will go on even after an FM(C)T has entered into force. Access of inspectors to these sites will not be possible. Also in NNWS, there are secrets in production plants, however they are commercial and special managed access procedures are used to protect them.

Nevertheless, which kind of production could go on in such facilities? Some of them were indeed co-located with fissile material production, namely plutonium reprocessing, and would be classified as a shut down former production facility in the FM(C)T context. Some NWS rework old warheads in order to extract the accumulated americium from the ageing plutonium. But none of these activities release the effluents that are typical for reprocessing. Taking environmental probes outside such a location therefore is a method that gives credible results.

5.4.2 Facilities containing secrets

The problem of "difficult" facilities is frequently raised by delegates from several NWS, claiming that there are facilities at which safeguards are not applicable, but they do not elaborate much. A distinction must be made between two aspects: Firstly, the facilities may contain secrets, as explained above. Secondly, and different to the secrecy problem, there might be other technical difficulties for the implementation of safeguards which will be discussed in the next section on facilities not designed for safeguards.

The fact must be taken into account that, because of 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 enhances the significance of containment and surveillance techniques with additional managed access provisions. Following categories of facilities could be distinguished:

1. Ordinary facilities included in the normal procedures as defined.
2. 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 special managed access provisions. As a consequence, material accountancy in the interior might not be possible for a certain period. This period, in which the inspected state removes the sensitive information, must be limited and declared. But all exiting materials must be accounted

for and verified, and, depending on the extent of the verification agreed for other facilities, also all ingoing materials.

3. Former military facilities now closed at which sensitive information can still be found: The 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 could be possible in case of strong suspicions. For this kind of facilities, design information and knowledge about past production is not necessary as long as the verification needs only to assure that no production takes place after EIF. This provision might be helpful for those states that do not want to reveal past production to accede to the treaty.
4. Sites that store nuclear weapon materials produced prior to EIF. It is possible to verify that no production takes place from the outside by environmental monitoring.
5. Military nuclear weapon facilities not used for the production of nuclear materials such as refabrication or dismantlement factories: In NNWS, such facilities do not exist. Any verification activity inside of nuclear weapon factories will be very 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 takes place. It is also desirable to implement some verification at the entrance and exit in order to ensure that the total amount of fissile material transported, e.g. as warheads or warhead components, adds up to zero. Details of such verification arrangements, however, probably lie beyond the limits of what is possible within the FM(C)T and must be subject to future nuclear arms control and disarmament negotiations.

The Treaty must contain a provision which allows states to declare all problematic facilities according to categories similar to the ones explained above. For each of them, verification arrangements and time scales must be negotiated individually, e.g. between the state and the verification body. However, some general limits and guidelines can be agreed upon beforehand. There should be a provision for regular reviews and improvements of these arrangements. Interesting lessons can be learned from the *Trilateral Initiative* of the U.S., Russia, and the IAEA that sought to apply IAEA verification measures on weapon origin fissile material.[38]

5.4.3 Facilities not designed for safeguards

Today, in NNWSs, implementation of safeguards is already taken into account in the planning stage of a plant, and design verification takes place during construction. As a consequence, it is much more difficult to pursue unmonitored diversion paths. Plants in NNWS are well understood, and all their potential diversion paths are known and monitored.

38 Shea 1999; Shea 2003.

In contrast, facilities in states without full scope safeguards might pose difficulties for two reasons: Firstly, they might be constructed in a way that the installation of material balance areas and key measurement points will be physically difficult, be it for difficulty of physical access at some points, for an unfavourable construction and organisation of material flows or for partial contamination. This is especially the case for bulk facilities. Such problems, however, seem to be more of a technical nature. Remedies might be costly, but not principally impossible. In any case, each such facility that will not be shut down but converted for future civilian use will need an individual study and negotiation of how to establish some satisfactory verification. Probably, initial safeguards will treat the whole plant as a "black box".

Furthermore, it will be difficult to measure an initial inventory of a plant that had been in operation before being subjected to safeguards. Inside such a plant, there will be various material reservoirs in many different pipes and containers, with difficulties measuring masses and isotopic compositions. Measurements could be incomplete with high error margins. The documentation of past production might be unsatisfactory and contradictory. Even in NNWS, the IAEA occasionally stated so-called *material unaccounted for* (MUF), which, however, could always be clarified later, thanks to the material accountancy. The MUF is not necessarily diverted, but it is hidden somewhere inside the plant. But clarification needs access of the inspectors to the plant. For an initial period, there will be a limit of accuracy that must be accepted. It must be ensured that no additional undeclared operations take place in operating declared facilities. The error margins are reduced when the material going into a plant, e.g. spent fuel, had been accounted for already at the plant where it originated, e.g. a nuclear reactor. In the future, when more transparency is possible, methods of nuclear archaeology might apply, that analyse technical indicators in order to reconstruct the operation history of a plant.[39]

It is recommended to engage in cooperative studies that identify such facilities and investigate specific verification methods. This would include taking inventories, managed access procedures, and permanently installed measurements.

5.4.4 Verifying naval fuel production

Another problem can arise if some states want to keep the option to produce new HEU for naval fuel. 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 foreseen that verification of fuel in a "non-proscribed military activity" is renounced as long as the nuclear material is used in such an activity. Theoretically, the IAEA and the state shall 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.[40] So up to 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

39 Fetter 1993.

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

in the reactor, or it could also be applied to other facilities. Facilities and locations involved in naval fuel production are the enrichment plants, fuel fabrication plants, transports, storage, and the reactors themselves. The fuel elements seem to be a highly classified secret. INFCIRC/153 provides that the verification should follow the HEU until the insertion into the reactor. At the fuel factories, the fuel storage sites, and during transport, special managed access provisions should be worked out, e.g. using containers, tags, and seals. In any case, the safeguards provided for in the Agreement shall again apply as soon as the nuclear material is reintroduced into a peaceful nuclear activity. Verification procedures still would have to be developed to ensure that it is not diverted for other purposes. This has never happened in history, and there is no practical experience on how to provide assurance on the one hand, but to maintain the secrecy on the other.

It is incomprehensible why the owners maintain such extreme secrecy on their naval fuel. It is therefore hardly possible to create assurance that HEU, claimed to be used for military naval propulsion, is not be used for nuclear explosives instead. It is therefore highly recommendable to give up the exaggerated secrecy. This would also enable research and development of new fuels for naval reactors.

In case the option for the production of new HEU naval fuel will be kept open in an FM(C)T, starting and termination points of verification should be defined more precisely than in INFCIRC/153. Nevertheless, not verifying future naval fuel production would leave a loophole.

5.4.5 Verification problems because of black boxes of unverified materials

U.S. delegates between 2004 and 2009 claimed several further problems regarding verification that all deal with the unverified stocks produced prior to EIF: Firstly, without accountancy of material produced prior to EIF, accountancy of the material produced after is more difficult. Secondly, verifying non-diversion would be a problem, since states might swap safeguarded and unsafeguarded materials. Thirdly, it would be a problem to distinguish between materials produced prior or after EIF. This problem arises in plants formerly producing HEU that have been converted to LEU production. There are only very few such facilities.

With regard to the first problem, material accountancy of the total inventory of a state is in the center of NPT verification, and any inventory change is clarified. Accounting for the total inventory would indeed not be possible for an FM(C)T, as long as there is exempted material not accounted for. Nevertheless, it could be possible to establish an accountancy of materials produced after EIF. Verification must then confirm that no such material is diverted for undeclared purposes.

In case a state would 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 isotopic composition of the swapped materials. If the isotopic composition would remain exactly the same, one might ask whether swapping is a problem at all. Perhaps, swapping also happened in the past with British and French civilian and military nuclear materials. Nevertheless, the probability that swapping could be detected would be enhanced by monitoring the storage sites and transports of direct-use materials produced after EIF.

The third problem – how to distinguish between materials produced prior or after EIF – 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.[41] The lowest detection limits are reported to be in the order of 10^4 to 10^5 atoms.[42] Inspectors normally use environmental sampling techniques in an inspected plant and analyze the isotopic composition. The quantities to be analysed therefore are very small, and since the buildup 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 would be available for comparisons. Unfortunately, today the NWS seem unlikely to offer such transparency. It would also be helpful to permanently install portable and continuous enrichment monitors, otherwise a detection within a sufficiently short time would not be possible.[43]

These problems need more study. It must also be kept in mind that in NWS, the same precision as that of safeguards in NNWS will not be possible for quite a while. The negotiators should think of face-saving procedures of how to clarify discrepancies that inevitably will arise.

5.4.6 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. There are different production methods, but for any kind of tritium production, neutrons are needed.[44] Two of the methods are industrially applied; the others would need either rare source materials or are ineffective. The most common and effective method for military production is breeding tritium from lithium-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 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. For example, Canada

41 For plutonium: Wallenius/Mayer 2000; Chen et al. 2009, for HEU: Glaser/Bürger 2009; LaMont/Hall 2003; Hall 2005.

42 Glaser/Bürger 2009.

43 Glaser/Bürger 2009.

44 Described in detail by Kalinowski 2004.

is an exporter of tritium, claiming that this is only for peaceful uses.[45] 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 of tritium production for nuclear weapons will be part of an FM(C)T scope, it may nevertheless pose problems for verification, because of the neutrons that are needed for its production. Any neutron source, reactor or accelerator, can be used for both, either plutonium or tritium production. Thus, any strong neutron source will need to be verified for the non-production of plutonium for weapons.

And indeed, NWS used their military production reactors for both. For a while, dismantlement of nuclear weapons provides enough tritium, so for some NWS new production was not necessary for a while. But plans for a resumption of the production are already underway.[46] Current U.S. plans involve the irradiation of control rods containing Li-6 in commercial light water reactors. Russia produces tritium by irradiating Li-6 targets in a LWR and an HWR at Chelyabinsk-65. This way, the tritium demands will be met in the foreseeable future. Dismantlement of warheads yields additional tritium for many years.[47] China used the same reactor for plutonium and tritium production. Britain used four military production reactors at Chapelcross. It also purchased tritium from the U.S. at certain times.[48] France also used plutonium-producing reactors for its tritium, located at Marcoule, Valduc et Bruyères-le-Châtel.[49] India's is extracting tritium from the deuterium coolant of its CANDU reactors, at its Bhabha Atomic Research Centre.[50] Pakistan operates an unsafeguarded reactor at Kushab which can produce both plutonium and tritium.[51] Israel fabricates tritium by irradiating Li-6 in its HWR at Dimona.[52]

Verification must ensure that no plutonium is produced for undeclared purposes, but it is not necessary that it accounts for the quantities of tritium that may be 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. But they would not be included into the material accountancy which would account only for rods with fissile

45 This claim is contested within Canada. Domestic critics maintain that there is still too much transfer of tritium into the U.S. and other's nuclear weapon complexes.

46 U.S. Nuclear Regulatory Commission, Backgrounder: Tritium Production, June 2005.

47 Bukharin 2001.

48 Carey Sublette, British Nuclear Facilities, in: The Nuclear Weapon Archive, http://nuclearweaponarchive.org/Uk/UKFacility.html (16.12.2011).

49 Marc Philippe, François Besnus, Sources de production et gestion du tritium produit par les installations nucléaires, Rapport DSU n. 217, from: Autorite de Surete Nucléaire, Livre Blanc du Tritium, http://livre-blanc-tritium.asn.fr/etat-des-connaissances/ch1-1-source-de-production-et-gestion-du-tritium.html (16.12.2011).

50 Perkovich 1999, p. 427.

51 Carey Sublette Pakistan's Nuclear Weapons Program, Present Capabilities, http://nuclearweaponarchive.org/Pakistan/PakArsenal.html, Last changed 6 August 2001.

52 Marvin Miller, Appendix: Israel, Tritium, and Disarmament, in: IPFM 2010, pp. 44-45.

and fertile isotopes. Without precise accountancy of the Li-6 targets, no quantitative secrets would be revealed.

6. How to move forward? – Positive lessons from the CTBT-negotiations

For years, the international community expected progress in the Conference of Disarmament, but for years, it was disappointed again and again. Originally, the CD was deemed the most appropriate forum for the negotiations, because of its successful work in the early nineties when it negotiated the CTBT and the CWC. Negotiations were controversial, often, consensuses were blocked, but no one ever tried to block work as such. The precedent was the very end of the CTBT negotiations in 1996, after which the CD never again accomplished anything. Delegations had learned how to abuse the rules of the CD, and those who don't want an FM(C)T have an easy tool to prevent it.

The question must be asked whether the CD it is still the appropriate forum for the negotiations, or whether willing states should go outside and engage in work for the FMCT in a new forum. They must be willing to take the risk that other delegations whom they would like to see as party to the treaty will initially abstain. Similar risks were taken when other arms control treaties were negotiated. But history has shown that states sometimes decided later to join a treaty. The most prominent example is the NPT. The most visible cause of the current stalemate is Pakistan, but it is possible, that some others are happy about this situation without being too visible. They would not be interested moving the negotiations elsewhere, and the willing delegations should first start without them.

In spring 2011, several countries considered to move out of the CD and to start negotiations independently. Among them were a group of ten states that published a joint declaration (Berlin declaration) on April 30, 2011,[53] and the U.S., the UK and France.[54] The Berlin declaration states in the context of the begin of FM(C)T negotiations: " we underline that there is no reason and no excuse for further delay". It also mentions to ask the UN General Assembly to "address the issue and consider ways to proceed with the aim of beginning negotiations". Furthermore, it refers to a joint paper that "lists questions to be addressed by scientific experts" and favours the establishment of a group of scientific experts. The joint paper has not yet been published at the time of writing this report.

The idea of moving out of the CD was also consequently addressed during the session of the First Committee of the UNGA in 2011.[55] But it was decided the CD be given another

53 Berlin Statement by Foreign Ministers on nuclear disarmament and non-proliferation, Berlin 30 April 2011. The ten nations are Australia, Canada, Chile, Germany, Japan, Mexico, the Netherlands, Poland, Turkey and the United Arab Emirates.

54 Nations Weigh Taking Fissile Material Talks Outside Disarmament Forum, Global Security Newswire, NTI, May 17, 2001.

55 UNGA, Sixty-sixth session, First Committee, Canada: revised draft resolution Treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices, A /C.1/66/L.40/Rev.1.

year to start negotiations, however, "should the Conference on Disarmament fail to agree on and implement a comprehensive programme of work by the end of its 2012 session", "other options should be considered". Furthermore, the Committee encourages meetings "involving scientific experts on various technical aspects of the treaty", however, it still refrained from the establishment an official Group of Scientific Experts.

The problems described in section 5.4 call for detailed further studies. The discussions presented here show that there are approaches how to cope with the problems, but some of the suggested solutions still seem only superficially explored.

Verification of the CTBT had been studied for years before the start of the negotiations, by the *Group of Scientific Experts* (GSE). Their sessions took place during many years without CTBT negotiations. When the negotiations finally started, GSE was able to present solutions to various technical questions. Furthermore, it was possible to assemble several verification scenarios among which the delegations could chose. The experts presented the options in a way that the essential points were understandable for the diplomats. These fast results would not have been possible without the preceding work of many years and many experts on various fields from many countries.

Similarly, the studies that are necessary for an FM(C)T verification could be started by an independent Group of Scientific Experts, possibly with subgroups because the specific topics vary. The results would strengthen the confidence in the feasibility of verification, as they did for the CTBT. Critics of this idea fear that the experts' discussions could preempt negotiations. The GSE experts were nominated by their governments, and several were instructed to adhere to certain positions. Nevertheless, technical and physical aspects are facts whose negotiability is limited. Even if instructed, technical experts could create more clarity. Despite some restraints, the GSE experts were able to discuss verification in a scientific manner, as is confirmed by their results. The mandate of an FM(C)T group of scientific experts therefore should be limited to technical problems and should avoid discussing politics as far as possible. The members should be selected according to their professional expertise. If at all, their nationality should play only a limited role. An advantage of GSE was its continuity: The GSE mandate did not have to be renewed every year, the role of the chair was permanent and not subject to diplomacy such as rotation. Regarding the deadlock in the CD, a similar structure for an FM(C)T GSE would have a substantial impact on progress.

It remains to be seen whether a Group of Scientific Experts will be implemented that had been called for during the First Committee, and which role it will play in 2012. I recommend to let them work on specific aspects, such as those problems listed in section 5.4, and to task them with writing reports, but not to pre-negotiate the substance of the treaty. Instead, the experts should list the various options in a way that different potential positions are considered and point out specific problems that need further research. The international community should not wait any longer to let them start their work.

Furthermore, the willing nations should decide to start negotiations without the blockers outside the CD. This would probably leave a few delegations outside, but it would result in a process and finally in a treaty text. They also should refrain from a similar EIF clause as in the CTBT which is the reason that it is not in force today. Abstaining nations could join the process, or later, they could join the treaty. There are precedents in history, where states first abstained from a treaty but later adhered to it.

Otherwise, it is likely that the CD would be given yet another year of patience and after that again and again for years. I started to become interested in the topic in 1995 because of the exciting work on the CTBT that took place in the CD at that time, and I hoped that a similar experience would soon be repeated. Now I fear I might come back long after I have been retired and lecture on the same subjects as in this report, and still no more progress than in 1995 will have been achieved.

Appendix I: Figures of existing weapon usable materials

Table 1: HEU quantities world-wide, figures in tons

Possessor	For explosive use	Naval fuel	Declared excess	Technically disposed of (a)	HEU under IAEA safe-guards	In civilian use	Total
USA (b)	260	130	104 (c)	131 (c)	10 (d)	20	514
Russia (± 20 %) (b)	616	30 (e)	104	413	0	20	770
UK (b, f)	21.64 (g)		4.72 (g)		0	1.404 (h)	27.76
France (± 20%) (b, f)	26	1 (i)	0	0	0	4.9 (j)	25
China (± 20 %) (k)	16	??	0	0	0	1	16
India (b, l)		1.3 ± 0.5	0	0	0		1.3
Pakistan (b)	2.6 ± 1		0	0	0		2.6
Israel	??		0	0	0		
Non-nuclear weapon states (b)	0	0		0	7		7

Sources and remarks: (a) The HEU has been blended down to LEU by mixing it with depleted uranium.
(b) IPFM 2010, figures are as of mid-2010.
(c) Only parts of the excess HEU is enriched over 90 %, much is enriched to less between 20-90 % (Maerli 2002)
(d) McGoldrick 1995.
(e) Composed of 20 t fresh and 10 t spent naval fuel.
(f) All civilian nuclear material of the UK and France is under Euratom safeguards.
(g) Ministry of Defence, Historical Accounting for UK Defence Highly Enriched Uranium, March 2006. The UK report does not give figures of the HEU enrichment. The UK does not specify the average enrichment of its HEU, it neither specifies how much HEU is devoted to naval fuel (IPFM 2010).
(h) INFCIRC/549/Add.8/13, 16 August 2010.
(i) Number from ISIS-Online: "The bulk of France's nuclear powered vessels used LEU fuel. However, one or two of its strategic submarines used HEU fuel", http://isis-online.org/uploads/isis-reports/documents/military_excess_heu.pdf, updated 2005.
(j) Composed of 3.3 t fresh and 1.6 t spent fuel.
(k) Hui Zhang 2011.
(l) Enriched to about 30 %.

Table 2: Plutonium quantities world-wide, figures in tons

Possessor	For explo-sive use	Declared excess	Technically disposed of	Pu under IAEA safeguards	In civilian use	Total
USA	38	34	0	0		72
Russia (a)	88	53.9	0	0	47.7	189.6
UK	3.2	4.4	0	0	85.3 (b)	92.9
France	6	0	0	0	55.9	61.9
China (c)	1.8	0	0	0	0	1.8
India	0.24	0	0	0	3.5	3.74
Pakistan	0.1	0	0	0	0	0.1
Israel	0.8	0	0	0	0	0.8
Non-nuclear weapon states	0		0	0	45.6	45.6

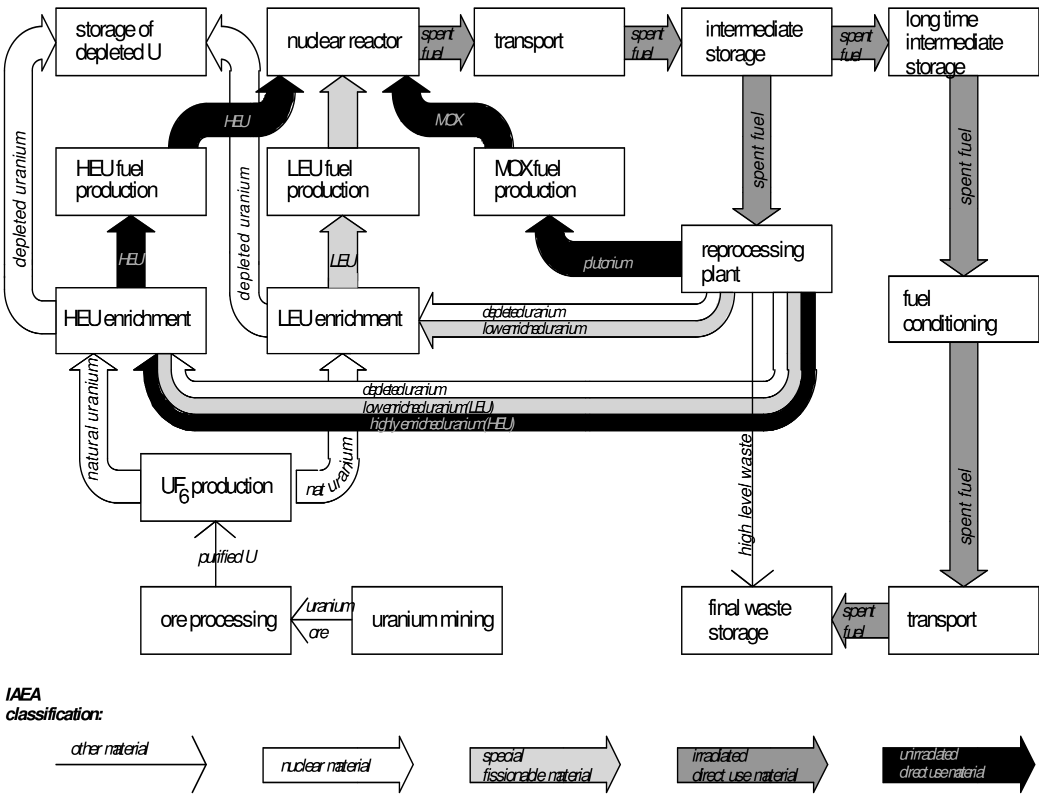
Source: IPFM 2010, figures are as of mid-2010, in tons.
Remarks:
(a) Russia possesses additional 6 tons of excess but undeclared plutonium.
All civilian nuclear material of the UK and France is under Euratom safeguards.
Uncertainties of the military stockpiles for China, France, India, Israel, Pakistan, and Russia are on the order of 10 – 30%.
(b) INFCIRC/549/Add.8/13, 16 August 2010.
(c) For details see also Hui Zhang 2011.

Appendix II: Fissile material, their IAEA categories, and their role for nuclear explosives

Material	Origin	IAEA Categories	Role for nuclear explosives	Remarks
"Weapon grade Pu": high content of isotope Pu-239	Short time irradiation of uranium in reactors, fast breeder blankets	Unirradiated direct-use material	explosive can be made from it	No legal distinction
"Reactor grade Pu": Pu-239 + substantial fractions of other isotopes (Pu-240, Pu-241 ...)	Long time irradiation in LWRs		explosive can be made from it, but with some technical disadvantages	
Pu-238 mixtures (> 80%)	Generated artificially by irradiation of Np-237	none	none	Use as heat generator
"Weapon grade" HEU: content of U-235 very high (> 90 %)	Enrichment	Unirradiated direct-use material	explosive can be made from it	No legal distinction
lower grades of HEU			explosive can be made from it, but its size increases with lower enrichment	
LEU: U-235 enriched to < 20%		Special fissionable material	enrichment necessary to make HEU, or neutron irradiation for transmutation into Pu	
natural U: U-238 with U-235 content = 0.7 %	Mining, refinement	Source material		
depleted U: U-235 content < 0.7 %	Tails from enrichment			
U-233	Irradiation of thorium in reactors	Unirradiated direct-use material	explosive can be made from it	Arise in thorium fuel cycles. Thorium resources are abundant
mixtures containing U-233			first separation from other mixture components to get U-233	
Thorium (Th-232)	Mining, refinement	Source material	Neutron irradiation to produce U-233	
Neptunium (Np-237)	Contained in spent fuel in substantial quantities; obtained by modern reprocessing	Flow sheet monitoring under voluntary IAEA arrangements	explosive can be made from it	Some countries plan to separate it
Americium (Am-241)	Contained in spent fuel in substantial quantities; separation difficult	Voluntary reporting of holdings and exports	explosive can be made from it, but only with extreme technical sophistication	Separation in large quantities not expected in the near future
MOX: mixture of U and Pu	Fuel fabrication for nuclear reactors	Unirradiated direct-use material	Pu must first be chemically separated	No legal distinction to other Pu
Fresh spent fuel: U-238 + U235 + Pu + highly radioactive isotopes....	Output of nuclear reactors	Irradiated direct-use material	Reprocessing in order to gain Pu	No legal distinction
Older spent fuel (> 10-20 years): U-238 + U235 + Pu + less radioactive isotopes....	Output of nuclear reactors after storage		Reprocessing, handling, and diversion is easier	
ore, ore residue (e.g. yellow cake)	Mining, refinement	none	natural U is made from it, IAEA: "other material"	Found all over the world
Tritium	Neutrons are needed for its production	none	for fusion processes during a nuclear explosion	Not "fissile"

Many nuclear materials may be abused for nuclear explosive purposes, but first some technical threshold must be overcome before it is converted into a nuclear explosive ingredient. The threshold is different for different materials. The IAEA categorizes the materials according to this threshold.[56] The lower the threshold, the stricter are the safeguards regulations. The tables shows several nuclear and other materials that play a role in regulations and negotiations on arms control, their most important origins, their IAEA categorizations, and their role for nuclear explosives.

The material flows in a closed fuel cycle based on uranium and their IAEA categories are illustrated in the figure:



56 International Atomic Energy Agency, IAEA Safeguards Glossary, 2001 Edition.

Appendix III: Acronyms

CD	Conference on Disarmament
CTBT	Comprehensive Nuclear Test Ban Treaty
CWC	Chemical Weapons Convention
EIF	Entry Into Force
FMCI	Fissile Material Control Initiative
FM(C)T	Fissile Material (Cutoff) Treaty
GSE	Group of Scientific Experts
HEU	Highly Enriched Uranium
IAEA	International Atomic Energy Agency
IPFM	International Panel on Fissile Material
LEU	Low Enriched Uranium
MUF	Material Unaccounted For
NPT	Nonproliferation Treaty
NGO	Non-Governmental Organisations
NNWS	Non-Nuclear Weapon State
NWS	Nuclear Weapon State
NTM	National Technical Means
P5	Permanent Five
UNGA	United Nations General Assembly

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