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Fissile Material Stocks: Characteristics, Measures and Policy Options

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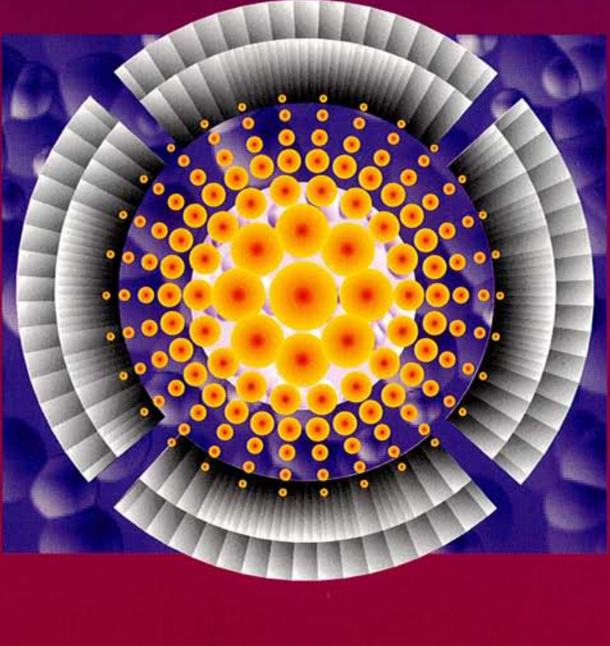
and
Frans Berkhout



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Preface

In 1995, the Conference on Disarmament (CD) agreed a mandate (the Shannon Mandate) for negotiations for a Fissile Materials Cutoff Treaty (FMCT, sometimes called FMT). However, because of political stalemate in the CD, the negotiating ad hoc committee was established only in August 1998. The treaty is intended to achieve a ban on the production of fissile materials for military purposes in a non-discriminatory, multilateral and internationally verifiably manner.

To support the negotiations in the CD, the United Nations Institute for Disarmament Research (UNIDIR) has commissioned a report entitled "Fissile Material Stocks: Characteristics, Measures and Policy Options". Prepared by two of the foremost experts in the field, Dr Frans Berkhout and Professor William Walker, the report addresses the issue of existing fissile material stocks which has emerged as a major concern within the context of the CD negotiations. Pointing to the implicit threat which fissile materials stocks pose to international security, some delegations at the CD have argued that such stocks should be included within the scope of an eventual treaty. Other delegations, however, have resisted such an inclusion on the basis that this would further complicate already difficult negotiations.

Stocks of fissile materials have accrued transnationally due to armament and disarmament processes, as well as to civil uses of nuclear power. However, little is known in the public domain about the nature, size and whereabouts of such stocks, and the complexities surrounding their regulation and control. This report on fissile material stocks seeks to begin to redress this problem by providing factual background information on all of these important matters. The report categorises and quantifies fissile material stocks, and examines the measures which have heretofore been developed regarding their control and management.

The report also includes an overview of broad policy options available to States in addressing the stocks issue, which could prove valuable in informing negotiations in the CD.

Whatever the outcome of these negotiations, the issue of fissile material stocks will continue to have salience until their complete disposal. UNIDIR hopes that this, and subsequent publications, will assist those researching and those negotiating, in the complex world of fissile materials.

Patricia M. LEWIS
Director
UNIDIR
March 1999

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William WALKER and Frans BERKHOUT[1]

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[1] William Walker is Professor of International Relations, University of St Andrews, Scotland, United Kingdom; Frans Berkhout is Senior Fellow, Science Policy Research Unit, University of Sussex, United Kingdom. They are co-authors with David Albright of SIPRI's *Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies*, Oxford: Oxford University Press, 1997. This paper is complementary to D. Albright and K. O'Neill (eds.) *The Challenges of Fissile Material Control*, Washington, D.C.: Institute for Science and International Security, 1999.

List of Acronyms

ABACC	Argentine-Brazilian Agency for Accounting and Control of Nuclear Materials
CD	Conference on Disarmament
CTBT	Comprehensive Nuclear Test Ban Treaty
EURATOM	European Atomic Energy Community
FMCT	Fissile Material Cut-off Treaty
FMT	Fissile Material Treaty
G8	Group of Eight
HEU	Highly Enriched Uranium
IAEA	International Atomic Energy Agency
INF	Intermediate-Range Nuclear Forces
INFCIRC	Information Circular
IPS	International Plutonium Storage
LEU	Low Enriched Uranium
MOX	Mixed-oxide (uranium-plutonium) fuel
MPC&A	Material Protection, Control and Accounting
NSG	Nuclear Suppliers Group
NNWS	Non-Nuclear-Weapon State
NPT	Non-Proliferation Treaty
NWS	Nuclear-Weapon State
PTBT	Partial Test Ban Treaty
SAGSI	Standing Advisory Group on Safeguards Implementation
SIPRI	Stockholm International Peace Research Institute
SQ	Significant Quantity
START	Strategic Arms Reduction Talks
USEC	United States Enrichment Corporation
WGU	Weapon-Grade Uranium

1. Introduction

The purpose of the Fissile Material Cut-off Treaty, as defined in the Shannon mandate of March 1995, is to achieve a "ban on the production of fissile material for nuclear weapons or other explosive purposes". The Conference on Disarmament (CD) was directed to negotiate a treaty that was "non-discriminatory, multilateral and internationally and effectively verifiable".

Plutonium and highly enriched uranium (HEU) are the fissile materials out of which all nuclear weapons have been constructed. Any fissile materials that are produced, for whichever reason, by parties to the new treaty after it enters into force will have to be submitted to international verification. This universal requirement will not, however, necessarily apply under the treaty to previously acquired stocks of material.

A number of States have argued that stocks should be brought within the scope of the treaty.[1] The concerns about stocks have arisen because large quantities of weapons-usable material already exist in the world, many of which could remain unsafeguarded. Such stocks could be used to acquire or reacquire nuclear weapons, thereby posing threats to national and international security. Stocks also raise issues of parity and equity. The States with nuclear weapon programmes possess unequal quantities and dissimilar types of fissile material, and the balance of safeguards obligations between nuclear- and non-nuclear-weapon States is unequal. In addition, care will have to be taken that stocks that are not covered by the treaty will not create loopholes that will diminish the treaty's effectiveness.

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[1] The word "stocks" is used throughout this paper to denote stocks acquired before the treaty enters into force.

A number of other States, prominent among them the nuclear-weapon States (NWS), have argued that stocks should play no part in the treaty whose primary objective—ending the production of fissile material for weapons purposes—should not be expanded. They have adopted this position partly in fear that inclusion of stocks would complicate an already difficult negotiation.

Recognising these different opinions and concerns, Ambassador Shannon noted in his report to the Conference on Disarmament that:

> "Some delegations expressed the view that this mandate would permit consideration in the Committee only of the future production of fissile materials. Other delegations were of the view that the mandate would permit consideration not only of future but that past production can be raised in the negotiation. Still others were of the view that consideration should not only relate to production of fissile material (past or future) but also to other issues, such as the management of such material."

Shannon's statement went on to record the delegations' agreement 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."

Given this background, Governments will have to consider whether and how to address the issues raised by stocks when the Conference on Disarmament begins its work in Geneva. This report is intended to provide factual background to these considerations. Our hope is that it will also contribute to an understanding of the particular complexities associated with the management and control of fissile material stocks. The report ends with an overview of policy strategies and options.

The following questions will be addressed:

(i) How may fissile material stocks best be categorized, and what are the main inventories of fissile material?

(ii) What measures have been developed recently in regard to fissile material stocks?

(iii) What broad options are available to States for addressing the stocks "problem" in a multilateral framework?

In discussing a draft of this paper with delegates to the Conference on Disarmament, we have become aware of the sensitivities attached to this treaty's title and acronym. In order to retain impartiality in the absence of consensus, we have adopted the unusual device of using the acronym FMT on odd-numbered pages (as befits its odd number of letters), and FMCT on even-numbered pages.[2]

Readers who are not already familiar with fissile materials and their controls are encouraged to read the accompanying appendices before proceeding further. Appendix A provides a brief introduction to fissile materials and their production processes. Appendix B describes the main instruments used to regulate fissile materials—physical protection and international safeguards—and explains how they are applied, by whom, when, and to whom.

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[2] This is akin to the solution adopted at railway stations in Brussels for the ordering of Flemish and French names on station signs. The Flemish/French and French/Flemish names alternate as one moves along the platforms.

2. Fissile material stocks: function, scale and distribution

Fissile materials have been produced for military and civil purposes since 1944. The stocks that have accumulated are large and various. How may they best be categorized? How much material is involved and where are the stocks located?

2.1 Characterisation by type of inventory

Stocks of fissile materials have arisen in three contexts:

- *armament processes*, in which material stocks are established to facilitate, and create options for, the assembly, testing and deployment of nuclear warheads;

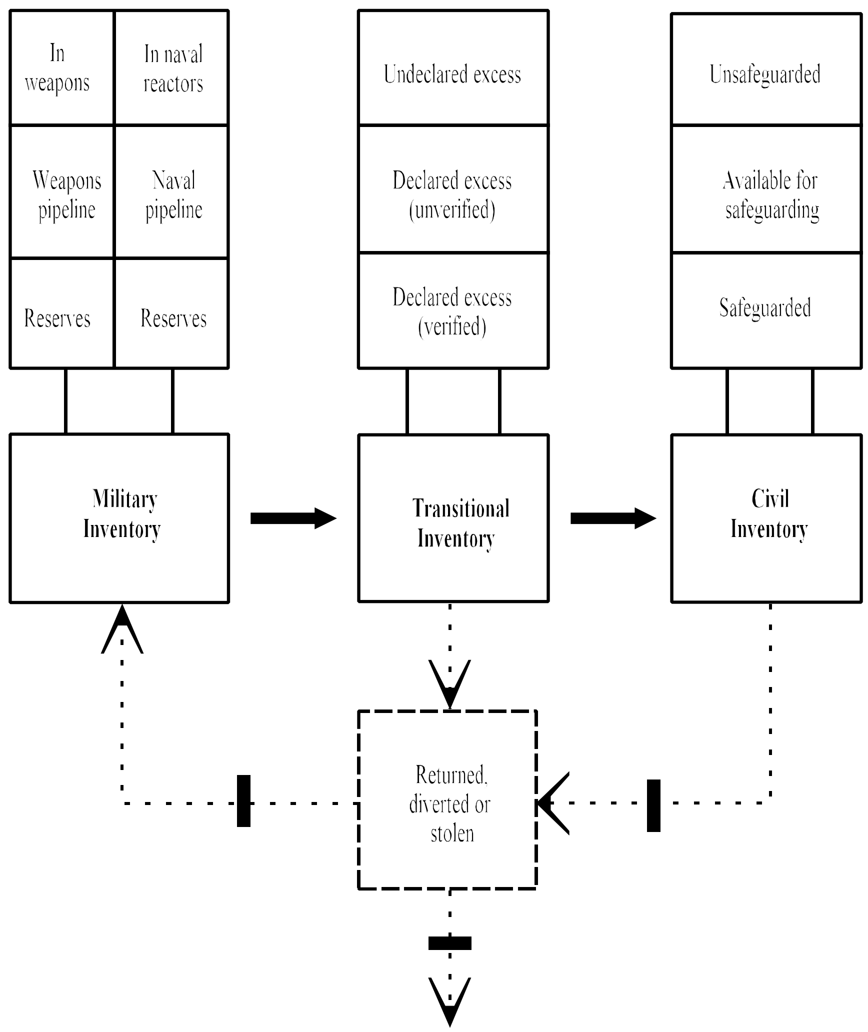
- *arms reduction and disarmament processes*, in which stocks of material accumulate after weapon dismantlement and the removal of redundant materials from military production cycles;

- *civil fuel-cycles*, in which fissile materials are produced, separated, stored and recycled for commercial or waste management purposes.

These contexts are associated with three types of inventory, as depicted in Figure 1. Note that the sizes of the boxes allocated for each category of material in this Figure are not in proportion to actual quantities.

The military inventory is dedicated to serving current or future military needs and is entirely outside international safeguards. The fissile material stocks attached to it are held in operational weapons or naval reactors, in the production system (sometimes referred to as the “pipeline”), and in reserves (including as weapon components). This inventory may also involve stocks that have been assembled outside safeguards to enable a State to acquire nuclear weapons at some future date.

Figure 1: Three types of inventory of fissile material



The transitional inventory comprises fissile materials that have been extracted from dismantled nuclear warheads and from other military stocks that are now surplus to requirements.[3] This inventory can be broken down into an undeclared inventory (i.e. one that has been removed from military usage but whose altered status has yet to be pronounced); an inventory that a State has declared to be excess to requirements; and the part of that declared excess inventory that has been submitted to international verification.

As implied, this inventory is in transition from a military non-verified condition to a non-military or civilian verified condition. This entails a number of steps and processes:

- the full accounting for, and technical characterisation of, plutonium and HEU contained within the inventory;
- a set of technological activities including the extraction of fissile material components from warheads, the processing and storage of those components, the transformation of materials from metallic to oxide form, and the treatment of scraps and wastes;
- investment in facilities able to perform the above functions and to store their products at each stage;
- the development of new and improved verification and safeguards approaches;
- the administration, management and financing of the above.

[3] We prefer the term "transitional" to the term "excess" when denoting this category of material for three reasons. Firstly, because the term excess can be deceptive: it is commonly used by NWS to imply that the materials that they declare to be excess equate to the total that is actually excess to military requirements. The "excess" can therefore disguise the true dimensions of the transitional inventory. Secondly, because "excess to military requirements" is an inappropriate term to use for the transitional materials located in disarming States, since they have no such requirements. Thirdly, because "transitional" implies movement and normative intent.

These steps may be complex, time-consuming and expensive. Materials in the military sector cannot be instantaneously transferred to the civilian sector.

The direction of movement for these inventories is from military to civil. There is, however, another form of transitional inventory (indicated in Figure 1) that potentially comprises materials that are being returned or diverted to military use, or that are being stolen for whichever purpose. The main functions of safeguards and physical protection are, of course, to prevent this reverse flow of material into the military sector and to stem its passage into unauthorised hands (see Appendix B).

The civil inventory comprises materials (largely plutonium) that have been produced and processed in connection with the generation of electricity in power reactors. This inventory is largely under International Atomic Energy Agency (IAEA) or European Atomic Energy Community (EURATOM) safeguards or is available for inspection under voluntary offer agreements with the NWS. There are, however, some civil stocks in States with weapon programmes (notably Russia and India) that have not been made available for international safeguarding.

Stocks in the civil inventory take four main forms:

- separated plutonium and HEU in store;
- plutonium and HEU in the reactor fuel fabrication process;
- plutonium contained in unirradiated mixed-oxide (MOX) fuel;
- plutonium contained in spent power reactor fuel, and HEU and plutonium contained in spent research reactor fuel.

2.2 The scale, type and location of fissile material stocks

The stocks of plutonium and HEU that exist today in the world are displayed, to the best of our ability, in Tables 1, 2 and 3, the first of which summarises the other two. No information is available on stocks of uranium-233, neptunium-237 and americium-241 which are presumably small but may still be militarily significant. (Tables 2 and 3 can be found on pages 12 and 14.)

Table 1
Inventories of plutonium and HEU, tonnes, end of 1997 (summary)

	"Military"	"Transitional"	**Subtotal**	"Civil" [a]	**Total**
Plutonium	80	150	230	180 (+1,000)	410 (+1,000)
HEU	560	1,200	1,760	20	1,780
Total	640	1,350	2,000	200 (+1,000)	2,200 (+1,000)

[a] The numbers in parentheses refer to estimated amounts of plutonium contained in stored spent fuel. The other figures in this column refer to separated material that has not been irradiated.
Source: Tables 2 and 3.

We limit ourselves to the following observations on Tables 1-3:

(i) ***Production moratoria*** (Table 2). Of the eight States with nuclear weapon programmes, four (France, Russia, the United Kingdom and the United States) have formally announced that they are no longer producing fissile material for weapons purposes. China has also indicated that a moratorium is in place. Israel's policy is unclear in this regard. India and Pakistan have active and possibly expanding production programmes, implying that their stocks of weapon-grade material are increasing.

(ii) ***Error margins*** (Tables 1-3). Bolded figures represent quantities that have been announced by States. Most of the figures relating to current and former military inventories are unbolded and are our own estimates. Many of these estimates carry **large error margins** (typically ±20-30 per cent for military stocks, and ±5-10 per cent for civil stocks) which have been left out to simplify presentation.[4] Although two States with weapon programmes (the United Kingdom and the United States) have taken steps towards making their inventories more transparent, the others have so far held to policies of opaqueness. Where question marks are inserted in Table 2, too little is known to make informed estimates.

(iii) ***Aggregate inventories*** (Table 1). Approximately 3,000 tonnes of plutonium and HEU exist in the world, of which 2,000 tonnes have been produced for military purposes. Of those 2,000 tonnes, around two thirds (1,300 tonnes) may now be considered "transitional" and as surplus to military requirements.

(iv) ***Cross-country variations*** (Table 2). There is great variation in the size of material holdings. Where military and transitional inventories are concerned, three groups of States can be identified: Russia and the United States whose stocks count in hundreds of tonnes each; China, France and the United Kingdom with tens of tonnes each; and India, Israel and Pakistan with hundreds of kilograms each.

The aggregates in Tables 1-3 are dominated by Russian and United States stocks. *It needs emphasising that there is no necessary correlation between quantities of material and their political and strategic significance.* Fifty kilograms in one location may give rise to greater concern than 50 tonnes in another.

(v) ***Inventories under international safeguards*** (Tables 2 and 3). Less than one per cent of the world stock of weapon-grade plutonium and uranium (12 out of 2,000 tonnes), and less than one per cent of the "transitional" stock (12 out of 1,300 tonnes), is currently under international safeguards. However, the picture is not quite as bleak as indicated here. Russia and the United States have announced that their declared excess plutonium will be submitted to international verification in due course, and the two States are working with IAEA to develop the necessary techniques and procedures to enable this to happen (see below).

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[4] For details of error margins, see D. Albright, F. Berkhout and W. Walker, *Plutonium and Highly Enriched Uranium 1996*, Oxford: Oxford University Press, 1997, chapter 14 *et passim*.

No weapon-grade plutonium or uranium is, to our knowledge, currently under international safeguards in China, France, India, Israel, Pakistan or Russia.

Around 60 per cent of fuel- and reactor-grade plutonium in civil fuel-cycles, including in spent fuel, is under routine IAEA INFCIRC (Information Circular) 153 or EURATOM safeguards. A further proportion is available for safeguarding under Chinese, Russian and United States voluntary offer agreements. A modest amount is under INFCIRC/66 safeguards in India.

For reasons of confidentiality, the precise quantities that are safeguarded in the States identified in Tables 2 and 3 are not published by safeguards agencies.

(vi) ***Civil inventories*** (Table 3). Following the agreement by nine States on the Guidelines for the Management of Plutonium (see below), the transparency of civil stocks of fuel- and reactor-grade plutonium has increased. Most civil plutonium is contained in spent fuel located in the industrial nations with substantial nuclear generating capacity (notably Canada, France, Germany, Japan, Russia, the United Kingdom and the United States).

Civil inventories of separated plutonium are heavily concentrated in France, Russia and the United Kingdom owing to their long involvement in civil reprocessing. Of these separated inventories, at least two thirds are "inactive"—they are held in store and form no part of recycling programmes. Stocks of separated civil plutonium in France and the United Kingdom are held under EURATOM safeguards, with a proportion being held under IAEA safeguards. The Russian stocks are unsafeguarded.

Table 2: Inventories of weapon-grade Plutonium and Highly Enriched Uranium[a], end of 1997, tonnes
(Bolded figures are announced quantities; unbolded figures are estimates)

	Still producing?	**Total acquired for military purposes**	**"Military inventory"**	**"Transitional inventory"**		
			Estimated requirements[b]	Estimated undeclared excess	Declared excess (unsafeguarded)	Declared excess (safeguarded)
Plutonium						
Russia	**No**	131	36	45	**50**	0
USA	**No**	**85**	36	11	**36**	**2**
China	No	4	3?	?	0	0
France	**No**	5	3	2	0	0
UK	**No**	**3.5**	1.6	1.6	**0.3**	**0**
India	Yes	0.4	?	?	0	0
Israel	?	0.4	?	?	0	0
Subtotal		229	80	60	**86**	**2**

HEU						
Russia	**No**	1050	260	290	**500**	0
USA	**No**	**645**	260	210	**165**	**10**
China	No	20	14?	6?	0	0
France	**No**	24	14	10	**0**	0
UK	**No**	**21.9**	14	8	**0**	0
Pakistan	Yes	0.2	?	?	0	0
Subtotal		1760	560	525	665	**10**
TOTAL		1990	640	585	750	**12**

[a] Figures for HEU are in weapon-grade equivalent. The announced British stock includes HEU that is not weapon-grade.

[b] Our illustrative estimates based upon calculations of (*a*) the quantities of plutonium and HEU that would be required to sustain nuclear weapon arsenals at START II levels, and at the reduced levels attained by the United Kingdom and France, assuming a certain allowance (1 SQ) per warhead; and (*b*) the quantities of HEU required to fuel naval reactors into the future. As most modern designs of nuclear warheads contain considerably less than a significant quantity of plutonium and HEU, the estimates in this column should be regarded as upper bounds even after allowance is made for materials held in the production “pipeline”.

Sources: D. Albright, F. Berkhout and W. Walker, *Plutonium and Highly Enriched Uranium 1996*; *Plutonium: The First 50 Years*, Washington, D.C.: US Department of Energy, February 1996; *The Strategic Defence Review. Supporting Essays*, London: HMSO, July 1998; governmental statements.

Table 3: Inventories of unirradiated fuel- and reactor-grade plutonium, end of 1997, tonnes
(Bolded figures are announced quantities; unbolded figures are estimates)

	Civil unirradiated (safeguarded)	Civil unirradiated (unsafeguarded)	Former military[a] (to be safeguarded)	**TOTAL**
Plutonium				
Russia	0	**28.1**	0	**28.1**
USA	0	0	**14**	**14**
China	**0**	**0**	0	0
France	**54.8**	0	0	**54.8**
UK	**60.1**	0	**4.1**	**64.2**
India	0	1	0	1
Subtotal	**115**	29	**18**	162
Belgium	**2.7**	**0**	-	**2.7**
Germany	**4.9**	**0**	-	**4.9**
Japan	**5.0**	**0**	-	**5.0**
Switzerland	**0.7**	**0**	-	**0.7**
Subtotal	**13.3**	**0**	-	**13.3**
Total, separated	**128**	29	**18**	175
Unseparated, in reactor spent fuel (some safeguarded)				1,000
TOTAL				1,180

[a] This quantity refers to fuel- and reactor-grade material produced in military production reactors that is being brought under international safeguards. The United Kingdom material in this column is now subject to EURATOM verification.

Sources: "Communications Received from Certain Member States Concerning their Policies Regarding the Management of Plutonium", INFCIRC/549/Add.1-9, IAEA, Vienna, 1997-98; D. Albright, F. Berkhout and W. Walker, *Plutonium and Highly Enriched Uranium 1996*.

3. Measures relating to fissile material stocks: recent developments

In this section, recent developments (or absence of developments) in the regulation of military, transitional and civil inventories will be briefly reviewed. The main conclusion is that much has been achieved in the 1990s but that even more remains to be achieved. It should also be noted at the outset that measures have had to be developed—except in regard to civil stocks in non-nuclear-weapon States (NNWS) parties to the Nuclear Non-Proliferation Treaty (NPT)—in a treaty vacuum. No treaty framework has yet been established to guide the regulation of stocks in the NWS or in the non-NPT countries.

3.1 Military inventories: continuing absence of international regulation

Military inventories of fissile material are not unregulated. They are subject to *national* controls, especially involving physical protection, which are often strict and effective. However, this internal regulation is not open to any external oversight. Nor are the institutions responsible for the inventories usually fully accountable to national legislatures.

Inventories of fissile material bound up with nuclear-weapon programmes have traditionally been kept outside all multilateral controls. Their size, form and whereabouts have been classified. This has not fundamentally changed in the 1990s. For States reliant upon nuclear deterrence, keeping fissile material stocks opaque to the outside world has been justified mainly on grounds that it helps to limit knowledge of nuclear arsenals and of weapon designs. Threshold States have been similarly loath to embrace transparency because it might compromise their ambiguous postures on nuclear weapons and narrow their options.

The absence of transparency on fissile materials contributed to the "security dilemma" that encouraged arms racing during the Cold War and that encourages it today in South Asia.[5] One of the FMCT's principal attractions is that it discourages arms racing by removing the option of expanding unsafeguarded stocks by legally justifiable means. In South Asia and the Middle East, particular significance is attached to the size of unsafeguarded fissile material stocks since they represent the potential size of India's, Israel's and Pakistan's weapon deployments. An imbalance in stocks may be equated to an imbalance in military capabilities and thus to an imbalance in power. Once weaponization takes place, or is suspected to be taking place, States are bound to become more sensitive to any imbalances.

None of the arms control or arms reduction treaties negotiated by the United States and the Soviet Union/Russia contain stipulations on fissile materials. They are focused primarily on missiles and warheads. The transparency on warhead numbers involved, for instance, in the Intermediate-Range Nuclear Forces (INF) and Strategic Arms Reduction Talks (START) treaties has not extended to fissile materials. One consequence is that the legitimate scale of military holdings of fissile material, unlike the scale of nuclear arsenals, has not been defined by treaty. The NWS have discretion over which materials they designate as military (or as "excess"). As a result, they have been able to continue holding large reserve stocks, albeit stocks that have diminished as arsenals have shrunk. Until formally addressed by arms control agreements, these reserve stocks will provide States with opportunities to reverse the arms reduction process.

The exclusion of fissile materials from arms control may soon, however, belong to the past. Fissile materials may be brought directly or indirectly into a START III treaty if, as is expected, this were to contain provisions to verify warhead dismantlement. In addition, measures to strengthen fissile material protection and accounting (see below) are in some contexts being extended into the weapons production system, and some States (especially the United Kingdom

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[5] The security dilemma refers to the actions of States faced with uncertainty over, or inferiority in regard to, adversaries' capabilities. Actions by those States to bolster their own capabilities provoke a corresponding reaction from the other States, leading to the action-reaction cycle that is the basis of arms racing.

and the United States), appear prepared to accept greater transparency in regard to their weapons infrastructures, a transparency that extends to fissile materials.

3.2 Transitional inventories: towards regulation and disposition

The emergence of large transitional inventories of plutonium and HEU was not anticipated in the NPT. Nor, as we have seen, have actions addressed to these transitional stocks been formally guided by arms reduction treaties. The steps taken have been largely ad hoc and have taken a number of forms:

- unilateral actions by NWS;
- coordinated unilateral actions, in which similar steps are taken by two or more States but without formal agreement;
- bilateral agreements, notably involving Russia and the United States;
- trilateral negotiations between Russia, the United States and the IAEA on verification techniques and procedures;
- the multilateral planning of plutonium disposition amongst the Group of Eight (G8) countries.[6]

Four areas of initiative will be briefly discussed here: on material accounting and self-auditing; on physical protection; on safeguards and verification; and on disposition.

3.2.1 Material accounting and self-auditing

Historically, the monitoring and measurement of fissile material stocks and flows have been less precise in weapon programmes than in safeguarded civilian programmes.

Material accountancy. There can be reasonable confidence that accounting systems in the civil and military domains are now equally effective in three of the

[6] The G8 consists of the Group of Seven advanced industrial countries plus the Russian Federation.

States with weapon programmes (France, the United Kingdom and the United States). In Russia, the inherited deficiencies in material accountancy are now well known. Since 1994, a wide-ranging programme to improve nuclear material protection, control and accounting (MPC&A) has been under way in Russia with funds and expertise drawn from, the European Union, Japan, the United States and other quarters as well as from Russia itself. This programme has entailed intergovernmental agreements, the provision of finance from national budgets (notably under the United States "Nunn-Lugar Program"), and cooperative projects involving weapons laboratories and other organisations. The aim is to establish an effective and uniform accounting system that will operate at all nuclear sites.

Little is known about accounting practices in China, India, Israel and Pakistan beyond those applied at civil facilities that are subject to IAEA safeguards.

Self-auditing. International confidence in the security and non-diversion of fissile material stocks has to begin with States' own confidence that they have full and accurate information about the materials under their jurisdictions. In the longer run, complete disarmament will require all States that have had weapon programmes to declare full initial inventories so that their materials can be brought under comprehensive safeguards. In the early 1990s, South Africa had to perform this task when submitting its materials to full NPT safeguards. Complete audits are also seen as essential to the disarmament of Iraq and North Korea.

Among the NWS, the United States has gone furthest in establishing and publishing its inventories of plutonium and HEU. In 1993, the United States Government embarked on the "Openness Initiative" which was intended to reveal the precise scale, forms and locations of fissile material acquired and used for military purposes. This has involved (*a*) reconstructing production histories of individual reactors and enrichment and reprocessing plants, and taking proper account of material losses during production, (*b*) assembling records of material consumption (notably in explosive tests), (*c*) establishing where current stocks are held and in which forms, and (*d*) ensuring the consistency of these sets of data.

The results have been published in stages. Detailed findings on plutonium were published in June 1994 and February 1996. The detailed findings on HEU are expected to be published in 1999. Where each material is concerned, broad aggregate quantities in the current inventory are revealed, along with detailed figures on historical production and consumption. The scale and location of inventories defined as excess to requirements are also being published in detail. The United States Department of Energy, which has managed American fissile material and weapon production programmes, has been surprised by how much it did *not* know about its inventories prior to carrying out these audits.

In 1997 the United Kingdom Government embarked on a similar project, announcing the total size of its fissile material stocks in July 1998. It is worth noting the rationale provided when the Government simultaneously committed itself to publishing the results of a more wide-ranging audit:

> "Eliminating nuclear weapons will require states which have had nuclear programmes outside international safeguards to account for fissile materials produced. We will therefore begin a process of declassification and historical accounting with the aim of producing by Spring 2000 an initial report of defence fissile material production since the start of Britain's defence nuclear programme in the 1940s."[7]

Hitherto, there has been no public commitment by other States with nuclear-weapon programmes to carry out similar exercises.

3.2.2 Measures to enhance physical protection

During the 1990s, much effort has been devoted to extending best practice in physical protection to as many countries as possible, and to strengthening physical protection at vulnerable sites. Attempts to establish effective international standards have so far involved the IAEA *Recommendations for the Physical Protection of Nuclear Materials* and the Convention on the Physical Protection of Nuclear Materials (see Appendix B). In regard to the former Soviet Union, we have already referred to the MPC&A programme that has sought to improve physical protection at all sites where fissile materials are located. In the joint programmes involving Russia and the United States, 150 facilities at 53 sites had been identified by early 1998 as containing pertinent materials, and

[7] *The Strategic Defence Review: Supporting Essays*, section 5, paragraph 28.

up-grades had been completed at 100 of those facilities with work proceeding on the remainder.[8]

This refurbishment of physical protection in the former Soviet Union has been one of the largest and most expensive arms control initiatives in recent times. One consequence of the MPC&A programme is that a large proportion of Russia's and of the United States' transitional stocks will be held in secure storage facilities when their construction is completed in the next few years. Particularly significant is the Mayak plutonium storage facility that is being constructed at Chelyabinsk. Concerns remain however that these programmes are inadequate to the task. It is also recognized that many of the gains from these initiatives may be lost if there is no recovery of the Russian economy.

Again, one should note that little is known in the public domain about the quality of physical protection in the other States with nuclear-weapon programmes.

3.2.3 Safeguards and verification measures

Little of the material in transitional inventories has yet been placed under international safeguards (see Table 2). Under the NPT, the NWS are under no obligation to bring this or any other fissile material under safeguards (see Appendix B for a discussion of NWS safeguards). The slow pace at which safeguards have been extended over excess plutonium and HEU has been due partly to the need to develop new approaches to verifying stocks that are held as weapon components and other "classified forms of plutonium". Because IAEA inspectors cannot be allowed access to information relevant to nuclear-weapon designs, classical safeguards measures may be inapplicable. The IAEA is therefore applying the term "verification" to sensitive material inventories until the situation is clarified.

In September 1996, a trilateral initiative was launched by the IAEA and the Russian and United States Governments to explore the technical, legal and financial issues entailed in bringing these stocks under IAEA verification. This

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[8] See J. Doyle, "Improving nuclear material security in the former Soviet Union: next steps in the MPC&A Program", *Arms Control Today*, vol. 28, No. 2, March 1998, pp. 12-18.

has involved technical workshops on verification methods, the development of a model verification agreement, and the discussion of financial options including the Nuclear Arms Control Verification Fund that has been proposed by the IAEA Director-General.[9] The current aim is to have agreements ready for signature in September 1999, with the first facility (probably at Savannah River in the United States) being placed under IAEA verification in January 2000.

The United States and Russian Governments have announced that their declared excess materials will be submitted to verification "once suitable arrangements have been made" and "as soon as practicable".[10] The verification is expected to be carried out within the framework of their voluntary offer safeguards agreements with the IAEA. It is likely that the verification or safeguards measures applied to these inventories will be mandatory and permanent. The provisions in voluntary offer agreements enabling materials to be withdrawn from safeguards will probably be suspended in this context.

Among other States with weapon programmes, only the United Kingdom has so far declared an "excess". The material, which is presumably in an unclassified form, will be placed under EURATOM safeguards.

3.2.4 HEU and plutonium disposition

In order to render arms reductions irreversible, the Russian and United States Governments decided early in the 1990s that materials released from dismantled warheads and other military inventories should not be held indefinitely in weapons-usable form. HEU should be diluted to low enriched uranium (LEU) and burned in commercial power reactors, and plutonium should preferably be encapsulated in radioactive waste through MOX recycling or "immobilisation" (see Appendix A).

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[9] Statement on behalf of the Russian Federation, the United States and the IAEA, Vienna, 22 September 1998.

[10] These are the terms used by the Russian and United States Governments respectively in their communications to the IAEA on policies regarding the management of plutonium (INFCIRC/549/Add.9 and Add.6).

A dual approach has therefore been adopted towards transitional inventories. Steps are being taken to ensure that it is effectively protected and can be brought under international verification; and steps are being taken to render, through disposition, the material inaccessible by technical means. The problem with the latter approach is that it is essentially long-term. The inventories are so massive that any disposition programme is expected to take twenty or more years to complete.

HEU disposition

In 1993, 500 tonnes of Russian HEU were purchased by the United States Enrichment Corporation (USEC) acting as executive agency for the United States Government. The material will be blended in Russia with slightly enriched uranium and transferred to the United States as LEU. The first transfers occurred in 1998. It is planned that 30 tonnes of Russian HEU will be disposed of annually through this scheme. An additional 10 tonnes of American HEU will be similarly diluted each year to LEU. The LEU will then be offered by USEC for sale to power-station operators. At this rate, it will take around 17 years to eliminate the HEU excesses that have so far been declared by Russia and the United States. The rate of disposition is being kept this low partly out of desire to protect enrichment industries.[11]

The controversy that has surrounded the USEC agreement since its inception need not be discussed here.[12] Suffice it to say that USEC's privatisation, the desire of natural and enriched uranium producers to protect their markets, and disagreements over pricing have complicated the programme's implementation. The disposition of excess HEU may be a slow and contentious process.

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[11] A programme committed to disposing of the whole transitional inventory of HEU would meet over 40 per cent of LEU demand over 20 years (or some 30 per cent over 30 years), reducing the need for enrichment capacity. Releasing natural uranium from strategic reserves will also have consequences for the uranium mining industry.

[12] A critical assessment of the HEU agreement is provided by R. Falkenrath, "The HEU deal" in *Avoiding Nuclear Anarchy*, Cambridge, Mass.: MIT Press, 1996.

It has been proposed by non-governmental organisations that the bulk of excess HEU in both countries should be diluted down to LEU in advance of its introduction to civil fuel-cycles. This would provide confidence that the material was becoming inaccessible at the earliest possible date. As yet, this proposal has not been adopted by Governments.

Plutonium disposition

Plutonium cannot be rendered inaccessible through dilution with uranium. Instead, the objective of achieving the "spent fuel standard" advocated by the United States National Academy of Sciences has been accepted by both Russia and the United States:

> "Options for the long-term disposition of weapons plutonium should seek to meet a 'spent fuel standard'—that is, to make this plutonium roughly as inaccessible for weapons use as the much larger and growing stock of plutonium in civilian spent fuel. Options that left the weapons plutonium more accessible would mean that this material would continue to pose a unique safeguards problem indefinitely."[13]

The United States Government has decided to adopt a "dual-track" approach entailing the development of both MOX recycling and immobilisation.[14] The Russian Government has opted for the single track of MOX recycling. Disposition is expected to begin with the construction in Russia and the United States of MOX plants sized initially to absorb 1.3 tonnes of weapon-grade plutonium per annum. At that rate, the disposition of 50 tonnes in either country would take nearly 40 years to complete. A lack of appropriate reactors for accepting MOX fuels is, in Russia, an important constraint on the rate of disposition.[15] The various technical, financial and organisational steps are

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[13] National Academy of Sciences, Committee on International Security and Arms Control, *Management and Disposition of Excess Weapons Plutonium*, Washington, DC: National Academy Press, 1994, p. 34.

[14] See *Technical Summary Report for Surplus Weapons-Usable Plutonium Disposition*, Washington, D.C.: US Department of Energy, 17 July 1996. Immobilisation entails the blending or encasement of plutonium in a matrix of high-level waste.

[15] There are four VVER-1,000 reactors in Russia capable of taking MOX fuel. Assuming one-third MOX loading, they are each able to utilize 260 kilograms of plutonium per year. The remaining plutonium will be burnt in the BN-600 fast reactor. A higher rate of plutonium consumption would require substantial modification of the VVER-1,000 reactors to take whole
(continued...)

being coordinated partly within the planning framework established by the G8 in 1996.[16]

The disposition problem is not confined to weapon-grade plutonium. Table 3 shows that large quantities of fuel- and reactor-grade plutonium have accumulated at reprocessing sites in France, Russia and the United Kingdom in particular. Further quantities will be separated there if existing reprocessing contracts are honoured. Some of the separated quantities will form part of MOX recycling programmes (this applies especially to French material). A considerable portion is, however, inactive as no such recycling plans exist. These inactive inventories may expand if plans for recycling "active" plutonium are not realised, especially in Germany and Japan. They would present a disposition problem of similar magnitude to that faced with weapon-grade material. As yet, no plans have been formulated in Russia, the United Kingdom and other affected countries for disposing of excess inactive material.

3.3 Civil inventories: the extension of transparency

The safeguards applied to civil stocks are described in Appendix B. In brief, all civil inventories of fissile material belonging to NNWS parties to the NPT, and to NWS and NNWS parties to the EURATOM Treaty, are routinely held under international safeguards. Among NPT parties, the effectiveness of safeguarding will soon be increased by the implementation of the INFCIRC/540 reforms. Some fissile material in civil programmes in China, Russia and the United States (and in France and the United Kingdom) has been made available for safeguarding under voluntary offer agreements with the IAEA; and some material associated with civil programmes in India, Israel and Pakistan is subject to INFCIRC/66 safeguards.

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[15] (...continued)
MOX cores, and beyond that the construction of new reactors for which there is little money. See N. Yegorov, "Prospects of utilization in Russia of weapons plutonium being released during nuclear disarmament", paper presented to the G8 Experts Meeting, London, 30 March 1998.

[16] The involvement of States besides Russia and the United States is necessary because MOX technology is being supplied by France and Germany and because they and other States are providing financial assistance.

Steps have also been taken in the 1990s to increase confidence that plutonium stocks will be used only for peaceful purposes and will be effectively protected and managed, through the development of new transparency measures. In December 1997, nine States announced their agreement on a set of Guidelines for the Management of Plutonium (INFCIRC/549). The nine States were Belgium, China, France, Germany, Japan, Russia, Switzerland, the United Kingdom and the United States.

The Guidelines bring two innovations to international plutonium management. Firstly, the Governments adhering to them expressed their commitment:

> "To management of plutonium in ways which are consistent with [their] national decisions on the nuclear fuel cycle and which will ensure the peaceful use or the safe and permanent disposal of plutonium. The formulation of that strategy will take into account: the need to avoid contributing to the risks of nuclear proliferation, especially during any period of storage before the plutonium is either irradiated as fuel in a reactor or permanently disposed of; the need to protect the environment, workers and the public; the resource value of the material, the costs and benefits involved and budgetary requirements; and the importance of balancing supply and demand, including demand for reasonable working stocks for nuclear operations, as soon as practical."[17]

Secondly, each Government has agreed to publish "with a view to increasing the transparency and public understanding of the management of plutonium:

(i) occasional brief statements explaining its national strategy for nuclear power and the nuclear fuel cycle and, against that background, its general plan for managing national holdings of plutonium;

(ii) an annual statement, in a [prescribed] format, of its holdings of all plutonium subject to these guidelines;

(iii) an annual statement, in a [prescribed] format, of its estimate of the plutonium contained in its holdings of spent civil reactor fuel".[18]

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[17] INFCIRC/549, paragraph 13.

[18] Ibid., paragraph 14.

First statements had been issued by the nine countries by the end of November 1998. The figures contained in them have been used in Table 3.

The Guidelines are a valuable step forward. However, the transparency measures only apply to plutonium in "peaceful nuclear activities";[19] disclosures are limited to broad aggregates; the Guidelines do not cover HEU, although all but China and Russia expressed their desires in notes verbales sent to the IAEA Director-General that HEU should be subject to similar guidelines; and India, Pakistan and Israel, the other States with significant inventories of separated plutonium, played no part in the negotiations and have not indicated any willingness to adopt the Guidelines.

It is also worth noting that the Guidelines fall far short of, and contain no reference to, the multinational storage or management of plutonium that was under discussion in the late-1970s and early-1980s. The International Plutonium Storage (IPS) proposals envisaged that excess civilian plutonium stocks would be placed under the supervision of the IAEA in accordance with Article XII A.5 of the IAEA statute. This article grants the Agency certain rights and responsibilities to "require deposit with the Agency of any excess of special fissionable materials recovered or produced as a by-product over what is needed for the above-stated uses in order to prevent stockpiling of these materials".[20] The Guidelines negotiated in the 1990s reflects a consensus since the IPS scheme's demise, that plutonium management will remain the sovereign responsibility of nation States and of operators under their jurisdiction. However, the option of placing fissile materials in the safe keeping of a multinational agency—an option that was central to the Baruch Plan of 1946 and the Atoms for Peace proposals of 1953—remains and may have to be revisited if and when complete nuclear disarmament is attempted.

[19] However, the United States chose to include information on declared excess stocks of plutonium in its statement.

[20] For a thorough discussion of these proposals, see C. van Doren, *Towards an Effective International Plutonium Storage Scheme*, Congressional Research Service Report No. 81-255S, Washington, D.C., November 1981.

4. Policy strategies and options

Two questions face Governments involved in the FMT's negotiation:

(i) How should stocks be addressed in the specific context of the FMT's negotiation, and what are the possible diplomatic approaches?

(ii) Which measures and agreements relating to stocks might be pursued with advantage inside or outside the FMT negotiations?

We should note at the outset that the "stocks problem" arises because there is no commitment to complete nuclear disarmament. If that commitment existed, the policy approach would be comparatively straightforward. A Nuclear Weapons Convention, or some such treaty, would require *all* States to submit *all* their materials to comprehensive safeguards at the earliest possible date; there might be complementary measures to dispose of all stocks of weapon-grade material, and to minimise stocks of fuel- and reactor-grade material; and if HEU continued to be required for naval reactors, a set of rules would have to be established governing its regulation that would apply equally to all States.

Until there is a commitment to complete nuclear disarmament, the task will be to achieve security at lower levels of armament while preparing the ground for complete disarmament. Given that a small minority of the world's inventory of fissile material (including its inventory of weapon-grade material) is now allocated to military programmes, it is worth repeating here a pair of observations made in our recent SIPRI book:

> "… today's *need* for stringent control over nuclear materials and facilities *is little different from that which would be required in conditions of total disarmament*.[21]

> "For both practical and political reasons, the regulatory situation in all countries, including the NWS, should be approached *as if the world is preparing for total nuclear disarmament*, whether or not that is a desirable or realistic prospect."[22]

Three additional observations are worth making at the outset of this section:

(*a*) Fissile materials do not constitute an autonomous field of policy. They are mainly the servants of nuclear deterrence and of the production of electricity. What is achievable and desirable on stocks will, in considerable part, depend upon broader strategic decisions and agreements. By the same token, the regulation of fissile materials can help to shape and uphold those strategic decisions and agreements.

In this light, Governments are currently confronted by two main "stocks issues". The first concerns the balance of military capabilities between States, and how that balance or imbalance affects security interests and thereby the FMCT's feasibility. This problem may only be resolvable at a high political and strategic level by the main protagonists in affected regions, such as China, India and Pakistan in South Asia. The second issue concerns the advancement and consolidation of nuclear arms reductions, nuclear non-proliferation and disarmament. In regard to both power balances and arms reductions, decisions on stocks (and their regulation) will be closely related to decisions on warhead deployments (and their regulation).

(*b*) Multilateral approaches, usually entailing broad agreement amongst States rooted in international law, are not necessarily the best approaches at a given moment. Their negotiation and implementation can impede action and innovation. But unilateral or bilateral approaches may also be inadequate: they can lack energy and coherence, and they may be difficult to implement and easy to reverse. Progress requires the selection of "horses

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[21] D. Albright, F. Berkhout and W. Walker, *Plutonium and Highly Enriched Uranium 1996*, p. 455.

[22] Ibid., p. 456.

for courses". Historically, progress in arms control has usually combined all types of approach—unilateral, bilateral and multilateral.

(*c*) Financial resources are scarce. All proposals concerning fissile material stocks need to be carefully costed and assessed in the light of other demands. One should recognise, however, that the risks arising from an underinvestment in control measures may be unusually high given the small quantities required for weapons and the ease of weapon acquisition if stocks of plutonium and HEU can be acquired without having to build production facilities.

4.1 Stocks and the FMT: possible diplomatic approaches

This section's aim is to identify the policy approaches and options that might be considered by Governments and by delegates to the Conference on Disarmament, though no attempt will be made to weigh their advantages and disadvantages.

Four broad diplomatic approaches may be identified. The order in which they are listed here implies no preference. The second and third approaches, and third and fourth approaches, need not be mutually exclusive—the best strategy might involve some combination of them.

(i) *Full incorporation into the FMT.* All pertinent issues relating to stocks of fissile material would be addressed in the treaty, which would contain a set of articles defining States' obligations on stocks and the rules and procedures that they would follow.

(ii) *Partial incorporation into the FMT.* Some issues pertaining to stocks would be addressed in the treaty (e.g. relating to the safeguarding of excess material) while others would be addressed by other means. Those included might be connected with the closing of potential loopholes and with measures already needed to implement the cut-off (an example being a no-withdrawal-from-safeguards commitment that could be universalised to include stocks).

(iii) *Normative guidance within the FMT.* The treaty would contain reference to concerns about stocks, expressing expectations that steps would be taken to address them. Language might be contained in the preamble and/or in the treaty's provisions. Two precedents could be drawn upon: the Partial Test Ban Treaty (PTBT) which looked forward to the Comprehensive Nuclear Test Ban Treaty (CTBT); and the NPT which looked forward to the CTBT and to nuclear disarmament. Following the NPT model, the linkage might be achieved through:[23]

- preambular language;
- one or more articles enshrining certain principles and objectives, and possibly pointing towards important next steps;
- periodic review of progress made in achieving the goals identified in those articles and/or in the preambule.

(iv) *Exclusion from the FMCT.* Stocks would not be addressed under the auspices of the FMCT, even if it were decided that the treaty should provide guidance as, for example, in (iii) above. Three approaches could be followed outside the FMCT, which are again not mutually exclusive:

- "business as usual", meaning that current measures would continue to be developed and implemented;
- special efforts would be made to hasten progress on specific issues (e.g. physical protection or disposition), involving unilateral, bilateral or multilateral initiatives as appropriate;
- a set of principles would be established to guide States' policies and regulatory actions on stocks. Those principles might, for instance, be centred on the four broad objectives identified below: *irreversibility*, *minimisation*, *effective protection* and *review*.

[23] We are grateful to Fred McGoldrick for this idea.

It is important to note that the tackling of stocks inside or outside the FMCT would become easier and more productive if they were also being tackled formally in arms reduction treaties. Indeed, there would be great advantage if the identification, declaration and regulation of fissile material stocks in transitional inventories could become an integral part of the arms reduction agenda, notably within the START process.

If States decided to address stocks outside the FMT, but to link their actions to the FMT in some way, they would face two other choices over the phasing of policy processes:

(*a*) *Parallel processes.* Stocks issues could be explored and pursued in a multilateral setting in parallel with FMT negotiations. This parallelism might entail strong temporal linkage, in which case agreement on a chosen stocks agenda would have to be reached prior to the FMT's conclusion; or it might entail weak or zero linkage, in which cases some progress would be necessary prior to the FMT's conclusion or the achievement would be left completely open-ended.

This multilateral addressing of stocks issues outside the FMT might best entail a number of parallel processes, focused on specific agendas, rather than a single all-embracing process. Of course, the "business as usual" approach already entails multiple processes but with little or no multilateral component.

(*b*) *Sequential processes.* Stocks issues could be addressed *after* the FMT's conclusion. One approach would be to embed a commitment in the FMT (or gain a commitment during its negotiation) to focus attention on these issues once the treaty had been negotiated.

There might also be advantage on some issues in another type of sequencing, entailing movement over time from agreement between the United States and Russia (having much the largest stocks), to agreement amongst all NWS, to universal agreement. This would shadow progress in START treaties and thus in warhead dismantlement.

4.2 Possible measures for reducing risks posed by fissile material stocks

The normative agenda relating to stocks may be encapsulated in four objectives, each of which has a range of possible measures associated with it:

(a) ***Minimisation.*** Stocks that are held in association with weapon programmes should be minimized to discourage arms racing and encourage confidence in the irreversibility of arms reductions. Associated measures include the FMCT, scaling of inventories, and limitation of transfers.

(b) ***Irreversibility.*** There should be no return or diversion of stocks to weapon programmes. Associated measures include safeguards and verification, self-auditing and transparency, and disposition.

(c) ***Effective protection.*** Stocks should be immune from theft and sabotage, and should not endanger health or the environment. Associated measures include universality of physical protection, and extension of treaty frameworks.

(d) ***Review.*** Measures taken to control fissile material stocks should be subject to periodic national and international review. Associated measures include a multilateral review process, and peer review of State practices on physical protection.

Each will be considered in turn below. Under each heading, the main measures will be identified followed by commitments already made by States and/or options for further development.

(*a*) Minimisation

The FMCT is itself a minimisation measure as it establishes a ceiling on stocks acquired for weapons purposes. However, there are currently no limitations on the inventories that may be assigned to weapons (except in regard to NNWS parties to the NPT); and NWS parties to the NPT, along with non-NPT

States, are not currently barred from acquiring new unsafeguarded stocks through transfers from other States.

Measure 1: End the accumulation of unsafeguarded fissile material stocks.

Existing commitment by NNWS parties to the NPT: No fissile material stocks will be acquired outside IAEA safeguards.

Existing commitment by four NWS:[24] Moratoria will be observed on the production of fissile materials for weapons purposes.

Existing commitment: The FMT will be negotiated in the Conference on Disarmament.

Option: Prior to the FMT's negotiation, all States could declare moratoria on fissile material production for weapons purposes.

Measure 2: Establish an appropriate scale of inventory to meet military requirements.

Option: States could commit themselves to retaining no unsafeguarded military inventories beyond those required to serve military needs.

Option: States concluding arms reduction treaties, and/or announcing reduced warhead deployments, could specify the aggregate quantity of material that would be used to service arsenals at the reduced levels. (One possibility noted above is that 1 SQ per deployed warhead would be set as the ceiling.)

Option: Stocks held temporarily in military reserves could be declared.

Existing commitment by nine States:[25] States recognize "the importance of balancing supply and demand [regarding fissile material], including

[24] France, Russia, the United Kingdom and the United States.

[25] Belgium, China, France, Germany, Japan, Russia, Switzerland, the United Kingdom and the United States.

demand for reasonable working stocks for [civil] nuclear operations, as soon as practical" (The Guidelines for the Management of Plutonium).

Option: This commitment could be embraced by all States possessing such civil programmes and stocks, and acted upon.

Existing commitment: State parties to the NPT, and adherents to the Nuclear Suppliers Guidelines, will not transfer fissile materials to NNWS (including non-Parties to the NPT) without IAEA safeguards being applied.

Option: This commitment could be universalised so that all transfers of fissile materials between States, including NWS, would be submitted to IAEA safeguards.

(*b*) Irreversibility

There are two aspects of irreversibility: legal and regulatory (measures 1 and 2); and technical (measure 3).

Measure 1: Extend IAEA verification/safeguarding of fissile material stocks.

Existing commitment: All stocks in NNWS parties to the NPT are submitted to full-scope IAEA safeguards, and all civil stocks in the European Union are submitted to EURATOM safeguards. All NNWS parties to the NPT will ratify and implement INFCIRC/540 (the safeguards reforms), and NWS parties will implement these reforms in line with their statements in May 1997 to the IAEA Board of Governors.

Option: All non-military material in NWS could be placed under full-scope verification/safeguards under voluntary offer agreements, so that all such material would be available for designation by the IAEA.

Option: States in certain regions possessing unsafeguarded stockpiles of fissile material could commit themselves to placing all or part of those stockpiles under IAEA safeguards at agreed annual rates.

Option: The five voluntary offer agreements negotiated by the NWS and the IAEA could be replaced by a single model safeguards document covering all peaceful nuclear activities (or all non-military material).

Option: The three non-NPT states with nuclear-weapon programmes could negotiate voluntary offer agreements with the IAEA, possibly in accordance with the above-mentioned model document.

Existing commitment by three States:[26] Declared excess stocks will be placed under international safeguards/verification at the earliest practicable date.

Option: This commitment could be extended to all States with weapon programmes.

Option: The voluntary offer safeguards agreements between the IAEA and the NWS could be amended so that fissile materials could no longer be withdrawn from international safeguards (or verification) for any reason.

Option: A special fund could be established to help finance the extension of safeguards/verification in States with weapon programmes.

Measure 2: Self-auditing and transparency.

Existing commitment by NNWS parties to the NPT: A full initial inventory of fissile material stocks is presented to the IAEA prior to the application of NPT safeguards; that inventory is routinely updated.

Existing commitment by two NWS:[27] A comprehensive inventory of fissile materials acquired historically for military purposes will be established, together with details of their consumption, forms and present locations.

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[26] Russia, the United Kingdom, and the United States.

[27] The United Kingdom and the United States.

Option: The establishment by States of accurate and comprehensive inventories of fissile materials, and their routine updating, could become a universal obligation.

Option: Agreement could be sought amongst States with weapon programmes on the information regarding these inventories that would be published. At minimum, the total stocks of weapon-grade plutonium and uranium held by States could be announced.

Existing commitment by nine States:[28] Annual declarations will be made on holdings of civil unirradiated plutonium, under the Guidelines for the Management of Plutonium.

Option: All States with holdings of plutonium could make annual declarations on unirradiated plutonium stocks similar to those required by the Guidelines for the Management of Plutonium.

Option: Annual declarations could be made by States on holdings of civil HEU. States could negotiate and adopt Guidelines for the Management of HEU equivalent to those established for plutonium.

Measure 3: Plutonium and HEU disposition.

Existing commitment by two NWS:[29] All fissile material declared excess to military requirements will be rendered inaccessible as soon as practicable through dilution (HEU) or by making it conform to the spent fuel standard (plutonium).

Option: This commitment could be embraced by all States with nuclear-weapon programmes.

[28] Belgium, China, France, Germany, Japan, Russia, Switzerland, the United Kingdom and the United States.

[29] Russia and the United States.

Option: States engaged in MOX recycling or in plutonium immobilisation could commit themselves not to separate the plutonium from resulting spent fuel or wastes.

Option: Time schedules could be agreed for the implementation and completion of disposition programmes (similar to the START treaties' schedules for weapon dismantlement).

Option: States with "inactive" civil stocks of plutonium could make commitments to dispose of them as soon as practicable and to draw up plans to achieve that end.

Option: All excess HEU could be diluted to LEU by the earliest possible date in advance of its introduction to civil fuel-cycles.

(*c*) Effective protection

Physical protection remains the responsibility of nation States. However, various collective actions could be taken to extend and strengthen physical protection.

Measure 1: Extending and strengthening physical protection.

Option: All States could commit themselves to adopt the IAEA *Recommendations for the Physical Protection of Nuclear Materials* (INFCIRC/225) and to sign and ratify the Convention on the Physical Protection of Nuclear Materials.

Option: Under the FMT, it could become mandatory for States to apply INFCIRC/225 physical protection measures at all sites containing fissile material, and to all materials in transit.

Option: A protocol to the Convention on the Physical Protection of Nuclear Materials could be negotiated to extend its coverage, including its coverage of materials in domestic contexts.

Option: A formal mechanism could be established, possibly in association with the IAEA, to review the efficacy of physical protection practices in nation States, and to conduct peer reviews of institutions responsible for physical protection.

(*d*) Review

Measure: Multilateral review processes for fissile material stocks.

Existing commitment: The IAEA safeguards system is continually reviewed by the IAEA Board of Governors and by IAEA member States, and the application of NPT safeguards is periodically assessed as part of the NPT review process.

Existing commitment: Progress on plutonium disposition is regularly reviewed by the G8.

Option: A process could be established, outside the NPT, to review progress across the whole field of the control of fissile material stocks and to advise on next steps. One possibility would be to incorporate this task in the periodic review of the FMCT's progress.

5. Conclusion

This paper has been prepared to provide information and ideas to Governments as they consider how to deal with the "stocks issue" in the context of the Fissile Material Cut-off Treaty. The underlying premise is that stocks give rise to a general problem—or set of problems—which needs to be addressed in some way and in some degree in a multilateral framework. Multilateral initiatives are desirable because important common security interests are at stake, and because current approaches are unlikely to achieve desired objectives on their own.

Care will have to be taken to address stocks in ways that are broadly acceptable, practicable and effective. It needs to be borne in mind that stocks are complex, dynamic entities which seldom lend themselves to easy, quick or cheap solutions; that some important initiatives have already been launched, especially by Russia and the United States, which should continue; that a multiplicity of approaches (domestic and international, bilateral and multilateral) is usually advantageous in arms control; and that for substantial progress to be made, *effectiveness* has to be the main criterion governing the choice of policy strategies and measures.

If it is judged unwise to incorporate stocks in the FMT's scope, then alternative multilateral processes will need to be considered. Those processes might be parallel or sequential, or parallel and sequential, to the treaty's negotiation. A valuable first step, which could be broached in parallel with the negotiation, might be to seek agreement on a set of principles that would define the broad obligations of States and guide their subsequent actions on stocks. This step need not preclude the search for agreement on specific measures.

Appendix A

Fissile materials and their production processes

No definition of fissile material has yet been drawn up for the FMT. The term is here taken to refer mainly to the isotopes of uranium and plutonium that can be fissioned by thermal neutrons.

A.1 Isotopes of uranium and plutonium

Uranium and plutonium are chemical elements. They invariably have 92 and 94 protons in their atomic nuclei respectively (their "atomic numbers"). Protons and corresponding electrons define the chemical properties of an element—the manner in which it combines with other elements.

Isotopes are forms of an element that are differentiated by the number of neutrons in the nuclei of their atoms. All elements have several isotopes, ranging from hydrogen's three at the light end of the scale to uranium's fourteen at the heavy end. The "mass number" of an isotope refers to the sum of its protons and neutrons. Thus uranium isotopes have mass numbers ranging from 227 to 240.[1] The usual nomenclature for these isotopes is uranium-227 and uranium-240 or ^{227}U and ^{240}U.

An element's isotopes have nearly identical chemical properties but very different nuclear properties. Some isotopes are highly radioactive, emitting

[1] The mass number 227 is comprised of 92 protons and 135 neutrons, and 240 is comprised of 92 protons and 148 neutrons.

energetic particles and radiations accompanying their "decay" to the isotopes of other elements. An example is the rapid decay of uranium-239 to neptunium-239 to plutonium-239. Other isotopes, including the isotopes commonly found in nature, are stable and long-lasting.[2]

Having no electric charge, neutrons can travel freely through atomic structures. They may nevertheless be "captured" if they collide with atomic nuclei. Thus uranium-239 is produced as a result of neutron capture in uranium-238. For some isotopes of heavy elements, atomic nuclei may break apart, or *fission*, when struck by neutrons. The most important of these *fissile* isotopes are uranium-235 and plutonium-239. When fissioning occurs, large amounts of energy are released together with additional neutrons which enable chain reactions to occur.[3]

Plutonium-239 exists in nature in insignificant amounts. Uranium-235 is abundant in nature but is found in a small fixed proportion relative to the uranium-238 with which it is always associated (0.7 per cent against 99.3 per cent). The quantities of plutonium and uranium isotopes required to manufacture nuclear weapons can only be attained through difficult and expensive production processes which happen to be very different.

A.2 Uranium enrichment, and grades of enriched uranium

Weapon designers usually prefer uranium that contains at least 90 per cent of uranium-235. The physical process by which this heightened concentration is

[2] The standard measure of an isotope's radioactivity is its half-life which refers to the time taken for half of its original mass to be transformed into other isotopes. The half-life of uranium-238 is 4.5 billion years whilst that of uranium-239 is 23 minutes.

[3] In such chain reactions, one neutron causes the release (upon fissioning) of two neutrons which cause the release of four neutrons and so on. On average, just over two neutrons are emitted per fissioned uranium-235 atom.

achieved is known as *enrichment*.[4] Most enrichment techniques exploit the slight differences in mass between uranium-235 and uranium-238.[5]

Five grades of uranium are commonly recognized:

1. Depleted uranium, containing less than 0.71 per cent uranium-235.

2. Natural uranium, containing 0.71 per cent uranium-235.

3. Low-enriched uranium (LEU), containing from 0.71 to 20 per cent uranium-235.

4. Highly enriched uranium (HEU), containing from 20 to 100 per cent uranium-235.

5. Weapon-grade uranium (WGU), containing from 90 to 100 per cent uranium-235.

Uranium containing less than 20 per cent uranium-235 cannot be used for explosive purposes. Thus the natural and low-enriched uranium used in power reactors has no direct relevance to weapon programmes.[6] This is recognized in the different safeguards standards applied to uranium with enrichments above and below 20 per cent. It also follows that HEU and WGU may be rendered useless for weapons purposes through simple dilution with depleted, natural or slightly enriched uranium.

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[4] Normal chemical separation techniques cannot be used because uranium isotopes have nearly identical chemical properties.

[5] The principal techniques are gaseous diffusion, centrifuge enrichment, the jet nozzle technique and electromagnetic separation. Other techniques which have been explored but not yet used on any scale include laser and chemical enrichment, the former involving the selective excitation of uranium isotopes and the latter a chemical exchange process.

[6] The amount of separative work required to produce HEU is nevertheless reduced if the feed material to an enrichment plant has already been enriched in uranium-235 to some degree.

A.3 Plutonium production, and grades of plutonium

Plutonium is produced in two stages. Firstly, uranium is "irradiated" with neutrons in a nuclear reactor. Some of the uranium-238 atoms capture neutrons leading to uranium-239 and thence to plutonium-239 through the decay path noted above. When discharged from a reactor, irradiated fuel is commonly referred to as *spent fuel*. In the second stage, plutonium is separated from uranium and from radioactive wastes contained in spent fuels by a set of chemical techniques known as *plutonium separation* or *reprocessing*.[7]

Plutonium-239 itself captures neutrons. As amounts of plutonium-239 build up in a reactor, higher-numbered isotopes in the sequence plutonium-240 to -243 also accumulate. They complicate weapon design as they are all, in different ways, highly radioactive. High concentrations of the relatively stable plutonium-239 are achieved by irradiating uranium fuels in reactors for a short time (typically one year).[8] In power reactors, where the objective is to produce heat and electricity for civil purposes, higher proportions of the other isotopes of plutonium are tolerated.

A distinction is commonly made between three grades of plutonium:

1. Weapon-grade plutonium, containing less than 7 per cent plutonium-240.[9]

2. Fuel-grade plutonium, containing from 7 to 18 per cent plutonium-240.

3. Reactor-grade plutonium, containing over 18 per cent plutonium-240.

The term "weapons-usable" has no precise definition. It is sometimes used to convey the message that most isotopic mixtures of plutonium can be used in nuclear weapons, or to imply that a given quantity of plutonium is in separated form and can thus be quickly introduced into weapon manufacture.

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[7] Chemical separation can occur because uranium and plutonium are different elements.

[8] "Burn-up" is the technical term used to indicate the extent of irradiation.

[9] "Super-grade plutonium" is sometimes used to describe plutonium containing less than 3 per cent plutonium-240.

All grades of plutonium can be used to manufacture nuclear weapons. They are therefore handled identically by safeguards agencies.[10] Another consequence is that plutonium cannot be rendered useless to weapon designers by diluting it with other plutonium. Plutonium disposition is more complex than HEU disposition. The favoured approach entails embedding the plutonium in radioactive material to increase its inaccessibility. This can be achieved by burning the plutonium in power reactors.[11] Alternatively, the plutonium can be "immobilised" by blending it with, or encasing it in, radioactive nuclear wastes outside reactors.

A.4 Critical masses and significant quantities

A critical mass of fissile material is the minimum quantity that is capable of causing a nuclear explosion by sustaining a chain reaction. Modern nuclear warhead designs typically use 3-4 kilograms of plutonium and/or 15-30 kilograms of HEU.

The *significant quantities* (SQs) of plutonium and HEU identified by the International Atomic Energy Agency (IAEA) are the minimum quantities that must be accounted for over a given period. They calibrate the safeguards system by determining the standards of accuracy.[12] Significant quantities approximate to the amount of material that a State would need to manufacture its first nuclear explosive. They are set at 8 kilograms of plutonium and 25 kilograms of HEU.[13]

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[10] The only category of plutonium that is exempted from IAEA safeguards is plutonium with an isotopic concentration of plutonium-238 exceeding 80 per cent.

[11] This is done by substituting plutonium for fissile uranium in mixed uranium and plutonium oxide (MOX) fuels. Although plutonium is not eliminated by this process, it is embedded in radioactive materials when discharged as spent fuel.

[12] In practice, safeguards agencies usually attain much higher standards of accuracy than implied by SQs.

[13] These quantities were chosen by the IAEA on advice from its Standing Advisory Group on Safeguards Implementation (SAGSI).

A.5 Other pertinent materials

All types of fissile material that can be used for weapons purposes will need to be identified in the FMT. Beyond those alluded to above, three others deserve mention. The first is the isotope uranium-233 which arises from the irradiation of thorium-232 in a nuclear reactor (thorium-232 is found in nature). Like plutonium, uranium-233 can be separated from irradiated thorium fuels by chemical reprocessing.

The second material is neptunium-237 which is produced through neutron capture when uranium-235 is irradiated. It is a stable material that is easy to handle, making it potentially useful to bomb designers.[14]

The third fissile material is americium-241 which is a decay product of plutonium-241. It is frequently stripped out of both weapon- and reactor-grade plutonium as it is highly radioactive and a nuisance in military and commercial activities. In theory, it could be used as a weapon material.

Fissile materials are used in both fission weapons ("atomic bombs") and thermonuclear weapons ("hydrogen bombs"). They are used in thermonuclear weapons to form the "primaries" whose explosive energy ignites fusion reactions in hydrogen isotopes. One of those isotopes, tritium, can be used to "boost" fission weapons thereby increasing the explosive yield that can be achieved with a given quantity of fissile material. However, tritium is not a fissile material under any definition and will not be covered by the FMCT.

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[14] Neptunium-237 could also be used commercially to produce plutonium-238 which has long found application as a heat source. For discussions of neptunium-237 and americium-241, see David Albright and Lauren Barbour, "Separated neptunium-237 and americium", in D. Albright and K. O'Neill (eds.) *The Challenges of Fissile Material Control*, Washington, D.C.: Institute for Science and International Security, 1999, pp. 85-96. The authors estimate that world inventories of americium and neptunium amount to some 80 tonnes, most of it contained in spent power-reactor fuels.

Appendix B

International safeguards and physical protection

There are two regulatory systems pertaining to fissile materials: international safeguards and physical protection (sometimes referred to as physical security). The objectives of international safeguards are (*a*) to provide confidence that materials that are being used, produced or stored in civil fuel-cycles, or that have been removed from military applications, will not be "diverted" into weapon programmes; and (*b*) to detect and provide early warning of clandestine production activities. The objective of physical security is, in our context, to ensure that nuclear materials will not be stolen and that facilities in which they are held will not be sabotaged.

Nuclear safeguards are applied only to civil and other non-military materials. They are implemented by dedicated inspectorates that are civilian and international, acting in cooperation with national authorities. Physical protection measures apply to civil *and* military materials. They are implemented by national authorities, including police and security services.

Nuclear safeguards entail what may be termed "limited transparency". Under IAEA safeguards, for instance, States transmit information to the IAEA Safeguards Division on condition that it remains confidential to that Division. This information is unavailable to other States, to other parts of the IAEA, and to publics. Physical protection carries no requirement for, nor expectation of, transparency.

B.1 Physical protection

Because of the character and coverage of physical protection measures, they do not form part of any "regime" grounded in international law. However, the building blocks of an effective physical protection system—one that endeavours to apply common standards and is subject to some international oversight—are gradually being assembled.[1]

The central text is the IAEA's *Recommendations for the Physical Protection of Nuclear Materials* which was drawn up in 1972 and carries Information Circular number 225 (INFCIRC/225). They have been revised on three subsequent occasions (the last being 1993) and a fourth revision is currently being negotiated. As the title implies, the *Recommendations* have the status of guidelines. They are voluntary and their implementation is not subject to verification. A strong expectation that States will follow the *Recommendations* has nevertheless taken hold.

In 1980, the first attempt to create a legally binding instrument was made with the conclusion of the Convention on Physical Protection of Nuclear Materials.[2] Its scope is narrower than the IAEA's *Recommendations*—it applies only to civil materials and mainly to their international transport—and the regulations contained in the Convention are less stringent than those in INFCIRC/225.

B.2 International safeguards

The IAEA is the world's primary safeguards agency. It is assigned the task of verifying compliance with the NPT. There are three types of IAEA safeguards:

1. full-scope safeguards on NNWS parties to the NPT;

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[1] A useful overview of developments in physical protection is provided by B. Jenkins, "Establishing international standards for physical protection of nuclear material", *The Nonproliferation Review*, Spring/Summer 1998, pp. 98-110.

[2] Its text was issued by the IAEA as INFCIRC/274.

(ii) Voluntary offer safeguards on NWS parties to the NPT;

(iii) Safeguards on States outside the NPT.

There are also two regional safeguards systems: EURATOM and ABACC.

B.2.1 *NPT safeguards on NNWS: INFCIRC/153 and INFCIRC/540*

The NPT requires NNWS parties to place all of their fissile material under permanent IAEA safeguards. The scope and implementation of these safeguards are described in the model document INFCIRC/153.[3] Amongst other things, they require an NNWS party to:

- provide an "initial inventory" of all pertinent materials under its jurisdiction;
- establish a "national system of accounting for and control of nuclear material" according to agreed IAEA standards;
- declare the facilities at which materials will be produced, stored and used;
- submit regular reports on inventory balances and changes;
- submit to IAEA inspection.

The discovery in the early 1990s that Iraq, an NNWS party to the NPT which was subject to full-scope safeguards, had mounted a huge clandestine weapon programme revealed serious weaknesses in the NPT safeguards system. In particular, the IAEA's access to design information and to sites was too constrained under INFCIRC/153. The IAEA's powers of detection were found wanting as a consequence.

The IAEA Board of Governors responded by initiating the "93+2 Program" which set out "to strengthen the effectiveness and improve the efficiency of the

[3] The release of INFCIRC/153 was dated June 1972.

present safeguards system". This entailed, in Part I, reassessing the safeguards practices that could be undertaken under the legal authority already provided by INFCIRC/153, and in Part II, negotiating a Protocol to INFCIRC/153 which would give the IAEA legal authority to implement additional measures. Parts I and II were approved by the Board of Governors in June 1995 and May 1997 respectively. The Part II measures now carry the designation INFCIRC/540.

B.2.2 *NPT safeguards on NWS: voluntary offer agreements*

NWS parties to the NPT are not obliged by the treaty to submit their materials to IAEA safeguarding. Each NWS has nevertheless agreed to place selected civil facilities on a "facilities list" and to open them for inspection if the IAEA wishes to "designate" them. Many civil facilities in the five NWS are now on such lists. The terms under which safeguarding can be carried out are contained in the "voluntary offer" agreements that the NWS have separately concluded with the IAEA.[4] The safeguards techniques are identical to those applied to NNWS parties, but obligations differ in the following main respects:

- civil and military facilities and materials may be kept outside safeguards at the discretion of the NWS;

- fissile materials may be withdrawn from safeguards, and facilities may be withdrawn from facilities lists;

- there is no requirement to establish comprehensive national systems of accounting and control.

There are, however, circumstances in which specific NWS have agreed to submit certain facilities and materials to permanent IAEA safeguards,[5] and

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[4] The INFCIRC numbers of the voluntary offer agreements are 263 (the United Kingdom), 288 (the United States), 290 (France), 327 (the Soviet Union/Russia) and 369 (China).

[5] One example is the Hexapartite Agreement which governs the safeguarding of civil centrifuge enrichment plants operated by its six signatory States (Australia, Germany, Japan, Netherlands, the United Kingdom and the United States). Under the Agreement, IAEA safeguards are mandatory and permanent for both NWS and NNWS signatories. Another example involves the IAEA's safeguarding of plutonium contained in spent fuels dispatched by Japan and

(continued...)

accounting practices at designated facilities must be compatible with IAEA standards.

The INFCIRC/540 safeguards reforms were not addressed to NWS parties to the NPT. When the new Protocol was concluded in May 1997, the NWS parties nevertheless made separate statements to the IAEA Board of Governors on the extent to which they would allow the Protocol to be applied on their territories under the voluntary offer agreements.

Over the long term, the safeguards reforms have obvious relevance to verification in States with weapon programmes, especially as they engage in deep arms reductions and disarmament. Complete disarmament will require confidence that any attempt by any State to re-establish a weapon programme will be detected at an early stage.

B.2.3 *Non-NPT safeguards: INFCIRC/66-type agreements*

States that have not joined the NPT are under no obligation to place fissile material stocks and associated facilities under international safeguards. The safeguards applied there have arisen out of supply arrangements negotiated when specific materials or facilities were being imported. They still follow the rules and procedures laid down in the pre-NPT safeguards document INFCIRC/66.[6] A small proportion of the fissile material stocks held in India, Israel and Pakistan are safeguarded by the IAEA under these arrangements.

Non-NPT parties are not legally required to set up national systems of accounting and control. India, Israel and Pakistan have also made no undertakings to accept the INFCIRC/540 safeguards reforms, and indeed played no part in their negotiation. Amongst all nation States, their safeguards situations may be regarded as the least well developed.

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[5] (...continued)
Switzerland to Britain and France for reprocessing. Equivalent quantities of plutonium are placed under permanent IAEA inspection at the reprocessing sites.

[6] The last version, drawn up in 1968, is commonly referred to as INFCIRC/66/Rev.2.

B.2.4 *Regional safeguards: EURATOM and ABACC*

EURATOM safeguards preceded NPT/IAEA safeguards and are based upon a different principle. EURATOM safeguards are rooted in the EURATOM Treaty which is binding on all member States of the European Union. Unlike the NPT, the EURATOM Treaty recognises no distinction between member States.[7] As a result, *all* States belonging to the European Union are required to submit their declared civil materials to EURATOM safeguards. In contrast to the other six States with nuclear-weapon programmes, all non-military fissile materials in the United Kingdom and France are thus under permanent international safeguards. However, States retain rights under the EURATOM Treaty to change the designation of materials from civil to military, thereby removing them from safeguards.

The thirteen NNWS members of the European Union, all of whom are NPT parties, are also subject to full IAEA safeguards under cooperative arrangements with EURATOM.[8] Only the United Kingdom and France therefore have rights to change the designation of materials within the European Union.

The Treaty for the Prohibition of Nuclear Weapons in Latin America (Treaty of Tlatelolco) does not establish its own safeguards system. Instead it delegates safeguarding to the IAEA. The same approach has been adopted for all subsequent nuclear-weapon-free zones. In 1991, the Argentine and Brazilian Governments established the Argentine-Brazilian Agency for Accounting and Control of Nuclear Materials (ABACC). All nuclear facilities and materials in the two countries are submitted to joint ABACC and IAEA safeguards. Following Brazil's ratification of the NPT in 1998, both States are now subject to full NPT safeguards.

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[7] Under article 86 of the Treaty, EURATOM also formally owns all special fissile materials within the European Union, although that right of ownership has not been exercised in practice.

[8] The INFCIRC/153-equivalent model document for European Union member States is INFCIRC/193. The British and French voluntary offer agreements are trilateral agreements between their Governments, the IAEA and EURATOM.

B.2.5 *Safeguards on traded fissile materials*

The NPT requires that all fissile materials transferred by treaty parties to NNWS shall be placed under IAEA safeguards. This requirement was endorsed by major supplier countries when they drew up the Nuclear Suppliers Guidelines (INFCIRC/254) in 1977. Adherents to the guidelines agreed in 1992 that henceforth no transfers would occur to countries that had not brought all fissile materials on their territories under IAEA safeguards (i.e. future transfers would depend upon acceptance of full-scope safeguards).[9]

Neither the NPT nor the guidelines bar the NWS from transferring fissile materials amongst themselves.[10] The NPT and the guidelines also allow transfers of fissile materials from NNWS to NWS parties to take place outside safeguards. The transfers of fissile materials (mainly HEU) contained in spent research reactor fuel from NNWS to NWS have, as a consequence, required no safeguards.

As India, Israel and Pakistan have acceded to neither the NPT nor the guidelines, they are bound by no multilateral agreements relating to transfers of fissile materials.

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[9] Russia has claimed that its recent agreement to provide reactor technology to India is the culmination of negotiations carried out before 1992, and therefore does not violate its full-scope safeguards pledge.

[10] Such transfers have, for instance, been carried out by the United Kingdom and the United States under the United States-United Kingdom Mutual Defence Agreement of 1958.

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