Transparency and Fissile Materials

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

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

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

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

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

The Demand for Transparency

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

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

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

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

there is confidence about the initial military inventory. In the longer run, complete disarmament will require a comprehensive and verifiable initial inventory of past production prior to these materials being placed under international safeguards.

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

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

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

Forms and Modes of Transparency

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

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

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

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

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

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

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The second aspect of transparency is: *what do they see*? Completeness, accuracy, timeliness and verifiability are key criteria for judging the quality of information that is made available through transparency measures. A range of options is available, depending on what is appropriate and feasible. With regard to nuclear materials transparency, the most demanding standards have been laid down by the IAEA's Standing Advisory Group on Safeguards Implementation (SAGSI). SAGSI criteria set out the level of accuracy and the periodicity with which nuclear materials accounts must be reported and verified to the IAEA. The criteria represent an international technical consensus about the standard of knowledge about fissile materials inventories which is required to be confident

that no safeguarded material is being diverted for non-peaceful purposes.[2]

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

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

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

The Scope of Transparency about Fissile Materials

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

Materials and facilities of concern

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

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

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

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

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

Transparency Measures

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

Internal transparency

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

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

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

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

Bilateral transparency

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

Agreement was reached in 1993 between the Russian Federation and the United States over the sale of 500 tonnes of HEU, to be partially blended down in the Russian Federation to LEU and transferred to the United States Enrichment Corporation for sale on world enrichment markets. A

set of bilateral transparency measures were negotiated at the same time. These were to assure the American side that material being transferred had come from military programmes, and the Russian side that the material was being put to peaceful uses. This has been achieved through declarations, materials accounting and mutual inspection of facilities. Public reports of the progress of the HEU disposition programme have also been made available.

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

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

Multilateral transparency

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

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

- a complete initial inventory of fissile materials;

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

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

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

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

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

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

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

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

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

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

Extending the Scope of Transparency

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

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

Table 1. Transparency measures applied to fissile materials

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

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

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

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

Notes

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

out by Israel's persistent criticism of IAEA safeguards.

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