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Looking for a Demarcation - between Nuclear Transparency and Nuclear Secrecy

PRIF Reports No. 68

Peace
Research
Institute
Frankfurt

The author is grateful to the MacArthur Foundation for funding the project "Transparency as a prerequisite of nuclear arms control". This report has been written as part of this project. She also wishes to thank Wolfgang K.H. Panofsky, M.V. Ramana, the group of advisors and authors of the transparency project and colleagues from PRIF for valuable comments. Many thanks also to Steve Pullinger who has taken great care with language editing.

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ISBN: 3-933293-95-2

Euro 10,--

Summary

Future progress in nuclear arms control and disarmament will be strongly dependent on an increase of transparency of nuclear-weapons-related information. However, much of the information on nuclear warheads and fissile materials that will be needed in verification is still shrouded in secrecy. Some of this information should be declassified, but that which is proliferation relevant should remain classified. Although nuclear transparency must have a limit, therefore, it is unclear where this limit should be placed: where an ideal demarcation between transparency and secrecy should lie. This report is the first publication of a project that aims to compare the transparency of several nuclear weapon possessing states. It aims to identify technical information that is relevant for nuclear verification, to discover whether it is publicly available or secret, and then to identify where the ideal demarcation line might lie.

There are several motives for secrecy: the first is non-proliferation. Detailed engineering and technical information has the potential to advance a proliferator's program substantially, for example, by sparing him time and money, and thereby also reducing the probability that the program will be detected before its completion. The second is national security, in order to ensure the survivability of the arsenal for deterrence, maintaining uncertainty about intentions and capabilities, hiding technological weaknesses or protecting technological superiority. A third motive might be status: The disclosure of technical information is sometimes seen as a surrender of status, and defeat. Fourthly, excessive secrecy may be because of democratic deficiencies. It could serve as a cover for mismanagement, crime, or corruption. It may also be abused by certain constituencies to set agendas that serve their special interests, to preserve autonomy in decision-making, to maximise their power-through-knowledge, and to avoid scrutiny by competitors or publics. Fifthly, a reason for secrecy could also be historic traditions and conservative inertia. Finally, those outside the NPT might want to minimise diplomatic pressure by revealing as little as possible about their nuclear weapon programmes.

Motives and criteria in favour of transparency can be best studied by using the example of the U.S. "openness initiative". It was designed to gain public trust through greater accountability, informing the public about all of the Department of Energy's activities. The Openness Initiative is unique in international comparison, not only because of its unprecedented detailed classification and declassification criteria that try to minimise any abuse but also because of the thorough and transparent public discussions that finally shaped its outcome. The major motivation was compliance with the U.S. Freedom of Information Act. As a result, the U.S. government has released a lot of data.

In order to enable progress in nuclear arms control, it is important to recognise that there are several levels of transparency. There is transparency between two NWS, between several NWPS as a group, between states including NNWS or inspection agencies, and transparency towards the public as a whole.

Information on nuclear warhead arsenals and deployments poses hardly any proliferation risk. Nevertheless, a lot of information is still secret which is mainly justified for na-

tional security reasons, notably protecting nuclear deterrence and ensuring the survivability of a state's nuclear retaliatory forces. Transparency of warhead stockpiles would give others a realistic image of capabilities. It would avoid unnecessary ambiguities and would contribute to the prevention of potential new arms races and competitions. And achieving greater transparency about nuclear warheads has been on the arms control agenda for several years. A special concern relates to warheads that are not yet covered by any control regime, but that are ready for use, namely, tactical nuclear weapons.

Verification measures also apply to the technical details of individual warheads. They seek to distinguish between a real and a fake warhead and its identification. But most of these technical properties are classified because their disclosure would be too risky in proliferation terms. National security reasons also play a role. But in any meaningful future nuclear disarmament, transparency of warhead dismantlement will be an important part. The pursuit of technical solutions to transparency problems have been investigated in detail by the US and Russia since the mid-1990s. The aim of these technical measures is to protect as much sensitive information as possible while at the same time to create the highest assurance possible that an object can be identified correctly. They become the more difficult to devise and to negotiate, the less information that is released.

Transparency of warheads would be incomplete if it was not supplemented by transparency in fissile material stocks and production facilities. Reasons for secrecy vary. In relation to the technical properties of warhead components, it is obvious that the reasons are the same as for secrecy on technical details of complete warheads. But there are examples in which the secrecy is hardly understandable. An example is Russian secrecy of the isotopic composition of its excess weapons plutonium. Transparency in fissile materials, especially on those from or for nuclear weapons, would create international confidence that the nuclear disarmament process is taking place as declared. It is also an important requisite for future nuclear disarmament verification, and it would facilitate international collaboration on improving material protection, control, and accounting (MPC&A) and preventing theft and smuggling.

In discussions on the need for nuclear testing and the scope and the verification of the CTBT, a variety of information plays a role. It includes information that facilitates verification of the CTBT and that is hardly proliferation relevant. Important information includes other experiments or activities that may replace nuclear tests such as the U.S. "science based stockpile stewardship". Some of this information does pose certain proliferation risks. On the other hand, it is information that is necessary in order to evaluate compliance with the CTBT.

The ideal demarcation between transparency and secrecy outlined in this report is still far from reality. A preliminary view shows that the U.S. is by far the most open, in comparison to the other NWPS. The differences between them seem striking. Much progress in nuclear arms control and disarmament can only be expected when there is progress in nuclear transparency in other NWPS. The reasons for the differences are still unclear and will be investigated in the further research of the project.

Contents

1. Introduction: nuclear transparency and secrecy

Future progress in nuclear arms control and disarmament will be strongly dependent on an increase of transparency of nuclear-weapons-related information. The more credible the verification, the more convincing the next steps in disarmament will be. However, much of the information on nuclear warheads and fissile materials that will be needed in verification is still shrouded in secrecy in several nuclear weapon states and weapon possessing states (NWPS).[1] If progress in nuclear arms control is to be meaningful, some of this information must be declassified. Examples of possible next steps that would be facilitated by more nuclear-weapon-related transparency are: verification of nuclear weapon disarmament (including disarmament of tactical nuclear weapons); a fissile material cut-off treaty (FMCT); projects and treaties on the disposition of excess weapons plutonium - and safeguards, projects and treaties on assistance for improving the security of fissile materials in Russia; further reforms of international safeguards, especially in cases where these are implemented in nuclear weapon possessing states outside the NPT; and the implementation of the Comprehensive Test Ban Treaty (CTBT).

The more information about nuclear weapons that becomes known, the easier and the more convincing will be nuclear verification. But there are counter-productive side effects: some of this information might be proliferation relevant e.g. it has the potential tobe useful in illegal nuclear weapon programs elsewhere. This is a major problem because intrusive verification goes to the heart of sensitive nuclear weapons information and might inadvertently spread knowledge that is better kept secret. Although nuclear transparency must have a limit, therefore, it is unclear where this limit should be placed: where an ideal demarcation between transparency and secrecy should lie.

“Knowing where the boundaries lie between classified and unclassified information can often be a key factor during the preparation for, and negotiation of, arms control and safeguards initiatives.”[2] Currently, the existing demarcation lines in the different NWPS vary substantially. Not only is any judgement as to whether certain information poses a proliferation risk inevitably going to contain an element of subjectivity, but also there are additional motivations for secrecy, none of which can be called truly objective. Examples of such additional motivations are “national security”, foremost of which is the desire not to reveal strengths or weaknesses in order to maintain ‘second-strike’ deterrence capabilities. But it can also be a cover for other motives e.g. concealment of corruption, anti-democratic attitudes, or simply conservative inertia because it has been the tradition to keep certain information secret.

1 In this report, the term “nuclear weapon possessing states” denotes the U.S., Russia, U.K., France, China, India, Pakistan, and Israel. The term “nuclear weapon state” (NWS) is restricted to NWPS that are NPT members.

2 Richard Comerford, The Role of Security and Classification in Arms Control and Nonproliferation, Proceedings of the 41st Annual INMM Conference, New Orleans, July 2000, on CD-ROM, available from INMM, inmm@inmm.org

This report is the first publication of a project entitled "Transparency as a prerequisite of arms control". The project aims to compare the current status and dynamics of transparency of the nuclear weapon complexes in the NWPS. Underlying questions concern the degree of declassification of information on nuclear weapons, the amount of such information that is publicly available, the origins and motivations of secrecy and transparency policies and initiatives, and factors currently influencing these policies. In the planned assessment, the prospects for changes towards more transparency favourable to nuclear arms control are identified.

It may be argued that some of the motivations for secrecy are not legitimate, in light of the nuclear weapon states' (NWS) obligations under Article VI of the Nuclear Non-Proliferation Treaty (NPT) and the ruling of the International Court of Justice that "There exists an obligation to pursue in good faith and bring to a conclusion negotiations leading to nuclear disarmament in all its aspects under strict and effective international control."[3] Although justifications for secrecy that are based on the assumption of indefinite possession of nuclear weapons might lose legitimacy under this reasoning, this project will look at those justifications irrespective of their legitimacy. The aim is to lay a basis for identifying prospects for changes to the status quo, via realistic and practical arms control and disarmament steps. These steps might ultimately also lead to the abolition of nuclear weapons.

This report has a modest scope. The planned country studies require a common reference, e.g. they need to look at secrecy and transparency of directly comparable information. The report, therefore, aims at identifying technical information that is relevant to nuclear disarmament and nuclear arms control verification, whether it is openly available in the countries to be investigated or not.

2. Origins and motives for secrecy or openness

2.1.1 Possible motives for secrecy

A superficial overview demonstrates that there are striking differences between the NWPS regarding the secrecy of nuclear weapons information. The U.S. is by far the most open, despite recent attempts by the Bush Administration to reverse the trend adopted by the preceding government.[4] At the other end of the scale is Israel, which still refuses even to admit that it possesses nuclear weapons. Nevertheless, some common motives can be identified amongst all NWPS:

3 International Court Of Justice, Advisory Opinion – Full Text: Legality Of The Threat Or Use Of Nuclear Weapons, 8 July 1996, http://disarm.igc.org/oldwebpages/icjtext.html

4 Documents on U.S. Secrecy and Openness Policy are being compiled by Steven Aftergood and made available at: http://www.fas.org/sgp/

(1) Secrecy as non -proliferation measure *:* The disclosure of certain technical details poses dangers for non-proliferation and could conflict with the commitments of nuclear-weapon states – under Article 1 of the NPT – not to share nuclear weapons know-how.

The information that today could accelerate a proliferator's nuclear weapon program, for example, details of how to construct nuclear weapons, fabrication of special materials, or fabrication of tools, should be kept secret. Some knowledge about nuclear weapons, which was originally classified in nuclear weapon states, has now become publicly known. But it consists mainly of general principles about the construction and functioning of nuclear weapons, rather than technical details. Most of this general information can even be found on the internet.[5] It does not make sense to classify knowledge that is already widely known.

In contrast to the basic information and nuclear science, detailed engineering and technical information has the potential to advance a proliferator's program substantially e.g. to spare him time and money, and thereby also reducing the probability that the program will be detected before its completion. Such detailed information, therefore, must be closely guarded. Although a determined would-be proliferant might be able to develop a nuclear weapons capability independently, continued classification can delay proliferation and make it more costly and less certain to succeed. Delay also makes detection more likely, and gives time for countermeasures.[6]

(2) Secrecy for national security: "National security" is the term that is usually used in order to justify secrecy on nuclear-weapon-related information. Often, the elaboration on what this means is vague. In the following, three variations of "national security will be examined: deterrence, uncertainty as strategy, and secrecy on the level of technological development.

(a) Deterrence: During the Cold War, deterrence was at the core of nuclear strategies for preventing both nuclear, and major conventional, war. It remains a fact of life today – between the U.S. and Russia, and between India and Pakistan. It is also an important part of the nuclear strategies of other NWPS. As a consequence, survivability of nuclear deterrent forces is essential. And survivability, in turn, can depend on various aspects of secrecy. Specifically, for example, maintaining secrecy about the location of nuclear weapons is essential to prevent successful pre-emptive attacks.

The extent to which nuclear deterrent strategies are still reasonable after the Cold War is debatable.[7] Many are questioning whether conventional deterrence would not be suffi-

5 Examples are: Carey Sublette, Nuclear Weapons Frequently Asked Questions, Version 2.25: 9/8/2001, http://nuclearweaponarchive.org/Nwfaq/Nfaq0.html; and Gerhardt Locke, Aufbau und Funktionsweise von Kernspaltungswaffen, Bericht INT 25, Euskirchen 1982 (not available on the Internet). Another site that offers many resources and links is: The Nuclear Weapon Archive – A Guide to Nuclear Weapons, http://nuclearweaponarchive.org.

6 The function of classification in delaying proliferation can be compared to that of export controls.

7 As an example, the U.S. and Russia still have vast arsenals of non-strategic nuclear weapons. NATO still deploys non-strategic weapons in Western Europe. It is disputed whether strategic weapons would not be sufficient for deterrence.

cient in most conflict situations. Nevertheless, these discussions surpass the aim of this paper. As long as deterrence strategies still exist, states will claim a need for secrecy. This paper questions whether this is a legitimate factor or whether it is only an excuse, and whether, for example, such secrecy needs to be applied to all nuclear weapon systems.

(b) Uncertainty as strategy: During the Cold War, uncertainty about intentions and capabilities – and the quest for strategic advantage – was part of the nuclear strategy of the U.S. and the Soviet Union. That legacy still lives on today. Nevertheless, in cases where uncertainty threatened a serious destabilisation of strategic relations, a degree of transparency has been achieved through arms control measures.[8] The secrecy includes capabilities and technical aspects because they can reveal information on military planning.

(c) Secrecy on the level of technological development: States often desire not to reveal the level of technological development they have achieved. The motive can either be to hide technological weaknesses i.e. bluffing about capabilities, or an interest in protecting technological superiority. Possessors want to prevent an adversary from designing countermeasures, such as anti-ballistic missile systems, and to be able to exploit any weaknesses. The behaviour and control of nuclear weapons in various environments such as extremes of temperatures etc. can have a bearing on survivability. Strategic nuclear planning is still being revised.[9]

(3) Secrecy as status: Secrecy traditionally has a special status in the nuclear complexes of nuclear weapon states, and is often associated with privileges. The disclosure of technical information is seen as a surrender of status, and sometimes as defeat. The belief that the possession of nuclear weapons confers a special status itself often results in greater secrecy. Scientists normally interested in openness, find themselves unable to gain rewards by publishing their research results when working on nuclear programs.[10] Therefore, they become dependent on the appreciation granted within the closed community of those scientists who undertake secret work. Hence they come to regard this secrecy as conferring a special status.

Politicians, dependent on the advice of experts, often err on the side of caution when considering whether to declassify nuclear information. Conservative bureaucracies favour guarding information.

(4) Secrecy because of democratic deficiencies: The less democratic a state is, the more the opacity can be used as a convenient cover for the evasion of uncomfortable criticism. Such criticism can emanate from citizens of the possessor state as well as from outside.

8 William Walker, Reflections on Nuclear Transparency and Irreversibility: the re-regulation of partially disarmed states, Background paper for Session Five of the Conference on the Fissile Material Cutoff, Schlangenbad, 25-27 July 1997.

9 On the U.S. see Harald Müller/Annette Schaper, US-Nuklearpolitik nach dem Kalten Krieg (U.S. Nuclear policy after the Cold War), HSFK- Report No. 3/2003, Frankfurt, English translation to be published.

10 Hugh Gusterson, Secrecy, Authorship And Nuclear Weapons Scientists, in: Judith Reppy (ed.), Secrecy and Knowledge Production, Cornell University, Peace Studies Program, Occasional Paper #23, October 1999, p. 57, http://www.einaudi.cornell.edu/PeaceProgram/publications/occasional_papers/occasional-paper23.pdf

The secrecy can also serve as a cover for mismanagement, crime, or corruption. Furthermore, secrecy may be abused by certain constituencies to set agendas that serve their special interests, for instance to preserve autonomy in decision-making, to maximise their power-through-knowledge, and to avoid scrutiny by competitors or publics.[11] Although each state has its own means of combating corruption and mismanagement, these do not always prove very effective . The more democratic a state is, the more legal limits are set against the abuse of secrecy. Bureaucracies that have always had the traditional "right" to manage national security issues with limited external control have little incentive to change. Moreover, the leverage for more transparency from outside is limited in those states. Even in democracies in which parliamentary control over military activities has been traditionally weak or limited, there is no proper basis for external transparency.[12] An example of such a democracy is France.

The most prominent example of how a democracy aims to prevent abuse is the U.S. Freedom of Information Act (FOIA), enacted in 1966. It provides to any person a statutory right of access to government information. "The basic principle of the FOIA is to ensure an informed citizenry, vital to the functioning of a democratic society, needed to check against corruption and to hold the governors accountable to the governed."

Nevertheless, examples of abuse of secrecy have come to light even in the U.S. One example is the level of secrecy attached to experiments conducted on humans. Steven Aftergood quotes a 1947 Atomic Energy Commission memorandum, which instructs that:

> It is desired that no document be released which refers to experiments with humans and might have adverse effect on public opinion or result in legal suits. Documents covering such work . . . should be classified "secret."

This memorandum itself was not declassified until 1994.[13] Aftergood also cites some examples of what he calls "pathologic secrecy", that are "applied far out of proportion to any requirements of national security and will lead to bad policy, sometimes on a large and expensive scale". Many examples of this can be found within defence procurement programs e.g. the failings of the Navy's A-12 attack aircraft program that did not come to light until a lot of money had been wasted.

(5) Secrecy because of historic traditions and conservative inertia: In history, all nuclear weapon programs have started in total secrecy, independently from democratic oversight. As suggested by Walker,[14] the first phase of a nuclear weapon program – decision-making and research and development – is almost exclusively secret. The second phase is the built up, when you find both secrecy and deception (usually exaggeration), which is typical for all programs. The third phase is maturity, as the program begins to

11 Walker, op. cit. (fn. 8).

12 Camille Grand, Nuclear Weapon States and the Security Dilemma, in: Nicholas Zarimpas (ed.), Transparency in nuclear warheads and materials, Oxford: Oxford University Press, SIRPI 2003, p. 32.

13 Steven Aftergood, Government Secrecy And Knowledge Production: A Survey of Some General Issues, in: Reppy (ed.), op. cit. (fn. 10).

14 William Walker, unpublished communication.

become more transparent, and the fourth phase would be arms reduction. As new programs come on stream you find these cycles repeated. These cycles seem to be present in several NWPS, although there are variations. As an example, the third phase – maturity – has not quite unfolded in Russia or China, even less in the NWPS outside the NPT. The reasons must be investigated. A preliminary explanation is conservative inertia: when mechanisms and incentives for changes are lacking, not much declassification or changes of policy can be expected. Individuals within the system or citizens of the state who would support more transparency do not see a way of starting a process in favour of change and, in any event also fear the consequences of trying. They prefer to keep their heads down. Declassification is a positive act, and poses the risk of revealing too much. Passive non-action has no immediate consequence, and keeping the status quo is often a little reflected attitude of conservative bureaucracies. The classification system does not provide any procedure in relation to how to declassify information. Sometimes this reflects a wider characteristic of the possessor state, but sometimes it is specific only to the nuclear complex.

An example of a nuclear program that has never proceeded beyond the first phase – utmost secrecy – is that of Israel.[15] Cohen and Graham criticise that its nuclear complex escapes any democratic control and develop suggestions of how to end the extreme secrecy.[16]

(6) Secrecy because of rejection of the NPT: States outside the NPT acquiring or possessing nuclear weapons i.e. India, Pakistan, and Israel, might have an additional motive for secrecy. Apart from their respective security concerns, these states want to minimise diplomatic pressure from the outside. The more details that become known about their nuclear weapon programmes, the more pressure comes from other regional players and the international community to push them to renounce the nuclear option and join the NPT. After the Indian and Pakistani nuclear tests in 1998, it might have been expected that this motive would become less important. Nevertheless, in all arms control attempts that try to incorporate these states, more transparency tends to be regarded as a "slippery slope" that could finally lead to more binding commitments that in the end draws both countries into an arms control or nuclear reduction treaty. There are different reasons why these states reject the NPT.

2.2 Motives and criteria for transparency: the example of the U.S. "openness initiative"

On December 7, 1993, the U.S. Department of Energy (DoE) announced its "Openness Initiative". It was designed to gain public trust through greater accountability, informing the public about all of the Department's activities, with particular emphasis on environ-

15 Avner Cohen, Israel and the Bomb, New York: Columbia University Press, 1998.

16 "An NPT for Non-Members", Avner Cohen and Thomas Graham Jr., Bulletin of the Atomic Scientists, May/June 2004.

ment, safety, and health matters. The Openness Initiative also directly addresses non-proliferation objectives by identifying and improving protection for truly sensitive information and by promoting "transparency" for non-sensitive parts of nuclear programs, worldwide.[17] It resulted in a reform of DoE's nuclear classification and declassification in 1998.[18]

The Openness Initiative is unique in international comparison, not only because of its unprecedented detailed classification and declassification criteria that try to minimise any abuse but also because of the thorough and transparent public discussions that finally shaped its outcome. These detailed advisory panel discussions about openness and classification, and which also made recommendations for public accessibility to government information,[19] resulted in a number of publications. The information considered goes far beyond the nuclear-weapon-related information examined in this report. One of the reasons for this initiative is the attempt to comply with the FOIA: "When the U.S. Government keeps secrets from its citizens, that action conflicts with a basic, constitutional right of citizens to be informed of their government's actions so that they can intelligently participate in governmental processes. A democracy's requirement for openness in government is in conflict with a government's need to keep some information secret for reasons of national security."[20]

The discussions on the Openness Initiative are mentioned here because they contain a number of aspects that are useful in the context of this study, including the motive of facilitating nuclear arms control. The Openness Initiative also gives a preliminary explanation as to why the U.S. is the most transparent among the NWPS, despite attempts by the current administration to reverse some of the achievements.[21]

Most of the reports cited above list a variety of motives for more transparency:[22]

17 Office of Declassification, U.S. Department of Energy, Washington, D.C. 20545, Draft Public Guidelines to Department of Energy Classification of Information, June 27, 1994.

18 Department of Energy, Office of the Secretary, 10 CFR Part 1045, Nuclear Classification and Declassification – Action_ Final Rule, 1008, http://www.osti.gov/osti/opennet/finreg.html.

19 Examples are: Responsible Openness: An Imperative for the Department of Energy, Openness Advisory Panel, Secretary of Energy Advisory Board, U.S. Department of Energy, Washington, DC, August 25, 1997, http://www.seab.energy.gov/publications/openness.pdf Albert Narath (Chair), Report of the Fundamental Classification Policy Review Group, January 15, 1997, http://www.fas.org/sgp/library/repfcprg.html; National Research Council, A Review of the Department of Energy Classification Policy and Practice, National Academy Press, Washington, DC 1995; http://www.nap.edu/books/0309053382/ html/ index.html; Daniel Patrick Moynihan (Chair), Report of the Commission on Protecting and Reducing Government Secrecy, Pursuant to Public Law 236, 103rd Congress, S. Doc. 105-2, March 3, 1997, http://www.fas.org/sgp/library/moynihan/index.html. More documents can be found at http://www. fas.org/sgp/.

20 Arvin S. Quist, Security Classification of Information, Volume 1. Introduction, History, and Adverse Impacts, Revised 2002, Oak Ridge National Laboratory, September 20, 2002, http://www.fas.org/sgp/ library/quist/.

21 The transparency policies of the U.S. and other NWPS and their origins will be investigated in detail in the further course of the overall project.

22 Op. cit. (Fn. 18, 21 and 20).

- Declassification has the advantage of promoting peaceful applications of nuclear energy by dissemination of scientific and technical information. It also promotes technology transfer for U.S. commercial interests.
- It enables peer reviews and exchange in the open academic community, which has the effect of improving the quality of science.
- It disseminates environmental, safety, and health-related information needed for an educated public discussion.
- It promotes public trust in government secrecy by providing complete and accurate information in a timely manner and ensuring that only information requiring protection is classified.
- It makes the work in the weapons laboratories more attractive and enables them to acquire better staff.
- Classification also has substantial indirect costs, which usually include the costs of preparing documents or fabricating hardware on "secure" equipment and in secure areas; costs of classified procurements; costs of inefficient communication between project personnel; of time that employees are required to spend in classification education and training; and costs of having to do the same research or development twice because the results from a classified program are not available to others and the work must be repeated.
- The release of information would have positive effects on foreign relations, arms control negotiations, treaty verification, and disarmament.

The Openness Initiative also emphasised the importance of clear criteria for judgements on classification or declassification that are explicable. It is stressed that the exclusive reason for classification should be national security. The reformed U.S. legislation rules that "in no case shall information be classified ... in order to

(a) conceal violations of law, inefficiency, or administrative error;
(b) prevent embarrassment to a person, organisation, or Agency;
(c) restrain competition;
(d) prevent or delay the release of information that does not require protection for national security or non-proliferation reasons;
(e) unduly restrict dissemination by assigning an improper classification level; or
(f) prevent or delay the release of information bearing solely on the physical environment or public or worker health and safety.[18]

These motives certainly fall into the category of "Secrecy because of democratic deficiencies" described in the preceding paragraph. They are the most difficult to identify in an analysis or to abolish in a reform.

The Openness Initiative also stressed the need for credibility of the classification system. Classifiers should consider whether the information is so widely known or readily apparent to knowledgeable observers that its classification would cast doubt on the credibility of the classification system. The original incentive for promoting democratic discourses is also reflected: classifiers should think about whether publication would benefit the public welfare, taking into account the importance of the information to public discussion and education, as well as potential contribution to economic growth. Some more basic principles aim at the same goal e.g. that classification policy must be unambiguously related to national policy and enunciated in a manner understandable by the public, or that information relating to environmental, safety, and health issues should be classified only when national security requirements clearly outweigh the public's need to know.

The definition of "national security" and non-proliferation is also specified, though not in great detail. Classification officers are required to assess.[18]

1. The extent to which the information would assist in the development of a nuclear weapon capability in a non-nuclear weapon state or in improvements to the weapons in a NWPS.
2. The costs in terms of time and money in acquiring the information.
3. Any national security impact; particularly the extent to which the information would assist an adversary nation to assess or counter U.S. capabilities and limitations.

One outcome of the Openness Initiative, has seen the U.S. government declassify a variety of information, including more details on warhead numbers, on technical information on warheads, on plutonium production and stocks, and on basic science related to nuclear weapons. They are summarised and published in DoE's "*Restricted Data Declassification*" (RDD) lists whose seventh version contains over a hundred pages of technical details that are now declassified.[23]

2.3 Different levels of transparency

In nuclear arms control and disarmament treaties, verification provisions usually regulate in detail the sharing of information between the parties. They also normally contain confidentiality clauses, i.e., the information is only shared between defined parties but not with outsiders. This applies to bilateral treaties such as START as well as to multilateral agreements, notably verification agreements with the IAEA. Information gained by the IAEA is confidential within this organisation and is not shared even with member governments or the Board of Governors, let alone with the public. IAEA safeguards techniques – similar to Euratom safeguards – therefore make use of technologies such as image and data encryption, in order to ensure confidentiality.[24] This confidentiality was a prerequisite for the member states to accept safeguards. A major reason was the fear that industrial secrets would be compromised by the publication of inspection details. Another reason is proliferation dangers. As an example, the design of an enrichment plant must be examined and verified in detail by the IAEA, but publication of that information would pose a proliferation risk. Nevertheless, safeguards are possible because of the special legal and technical provisions, and because of the willingness of the member states to share their information on this special level.

23 U.S. Department of Energy, Office of Declassification, Restricted Data Declassification Policy 1946 to the Present (RDD-7), January 1, 2001, available at the internet at: http://www.osti.gov/opennet/rdd-7.pdf

24 IAEA, Safeguards Techniques and Equipment, 2003 Edition, August 2003.

Sometimes, a state is willing to share information with a limited number of parties but not beyond. The reasons for this secrecy to a broader audience are comparable to the reasons for overall secrecy. Nevertheless, there is a difference: in cases where a NWS decides to share information – at least with a limited group of parties, it may be assumed that some prior decision-making has taken place and some positive motivation for at least limited transparency exists. This decision-making has probably included an evaluation of the boundary between secrecy and transparency. In contrast, in cases where all information is kept secret from everyone, it is not clear whether this is the result of a recent process of renewed decision-making, or whether the reason is more one of simply continuing established practice without quite knowing why.

In order to enable progress in nuclear arms control, it is important to recognise that there are several levels of transparency. There is transparency between two NWS, between several NWPS as a group, between states including NNWS or inspection agencies, and transparency towards the public as a whole. It is notable, for example, that possessor states are prepared to share certain information amongst themselves that they would withhold from non-possessors. Verification protocols therefore normally include confidentiality clauses. Transparency investigated in this paper looks at all levels of transparency, not only at availability of information to the general public.

3. Information related to nuclear arms control and disarmament

Future progress in nuclear arms control and further disarmament will only be possible if the participating states are willing to provide transparency in aspects that are necessary for verification, joint disarmament studies and confidence building. As verification procedures become more complex and sophisticated, the more secrets are touched upon during the verification process. In this chapter, some categories of information related to nuclear disarmament and arms control are discussed: How would the release of information facilitate disarmament and verification measures? Which proliferation risks would it pose? Are there additional reasons for keeping this information secret? Is it possible to depict a demarcation between transparency and secrecy that maximises the benefits and minimises the proliferation risks?

The information that is considered in this chapter is information on nuclear warhead arsenals and deployments, on technical details of nuclear warheads, on fissile material stocks and production facilities, and information related to nuclear tests.[25]

25 There is additional information that would also be worth considering, notably on military nuclear power and propulsion, on nuclear planning and strategies, or on intelligence on foreign countries. Although it is beyond the scope of this report, it is left open whether it might be incorporated in the overall project.

3.1 Information on nuclear warhead arsenals and deployments

3.1.1 Types of information

Information on nuclear warheads that could be useful for arms control includes numbers, identification codes and names, types, yields, ranges, operational status (whether deployed, reserve, in maintenance etc.), delivery systems, production history, and locations. Fetter suggests declarations that move in phases.[26] In the initial phase, total numbers of different categories would be released, i.e., total stockpiles, numbers of warheads at specific locations or in certain operational statuses. Later, the particular properties of each individual warhead could be declared.

So far, however, no NWS has published all these details, although most have made some statements or published documents providing some related information. The U.S. and Russia have exchanged information on strategic nuclear warhead delivery systems as part of nuclear arms control treaties – mainly START and INF. However, the major agreements on strategic nuclear arms between the two superpowers have focused mainly on delivery vehicles and launchers. Warheads were dealt with mainly through counting rules that attributed a certain number of deployed warheads to a specific delivery vehicle.

3.1.2 Reasons for secrecy

The release of this kind of information on nuclear warheads poses hardly any proliferation danger. An exception might be a situation in which the security of deployed arsenals is insufficient and the possessor state fears that terrorists might attack storage sites and capture warheads. Rumours existed that the Pakistani nuclear arsenal might be in this situation.[27] The most important reason why states might prefer to keep information on nuclear warhead deployments and arsenals secret is the fear that its revelation would weaken the security of a state and its allies because it would encourage a first strike and therefore undermine deterrence. But the question remains whether secrecy of locations must apply to all nuclear weapons. As an example, a retaliatory force would still be credible if it is exclusively based on nuclear-armed submarines.

Smaller nuclear powers might additionally favour a policy of quantitative ambiguity as a way of protecting nuclear deterrence until they have built a survivable nuclear retaliatory force.[28] In their view, geographical ambiguity can contribute to nuclear deterrence too, as well as ambiguity of other information such as yields, ranges, or operational status.

26 Steve Fetter, Stockpile declarations, in: Zarimpas (ed.), op. cit. (fn. 12), p. 129.

27 David Albright, Securing Pakistan's Nuclear Weapons Complex, Paper for the 42nd Strategy for Peace Conference, Warrenton, Virginia, 25.–27. October 2001, www.isis-online.org/publications/terrorism/stanleypaper.html; 68 Pakistan's Nuclear Dilemma, Carnegie Endowment for International Peace, Non-Proliferation Project Roundtable, 2. October 2001. Transcript: www.ceip.org/files/events/Paktranscript.asp.

28 Li Bin, Appendix 3A. China and nuclear transparency, in: Zarimpas (ed.), op. cit. (fn. 12), p. 50.

Big nuclear powers do not have this problem of asymmetry. Nevertheless, during the Cold War, the intrinsic secrecy of the Soviet System was a particular concern to the West and fuelled suspicions. The belief that uncertainty contributed to deterrence was a major motivating factor for secrecy on both sides. That it still prevails is shown by the following quotation from a U.S. report on inadvertent releases of classified information:[29]

> "The inadvertently released nuclear weapons utilisation information ... detailed in this report could assist potential adversaries in assessing the strengths of the U.S. nuclear arsenal."

Similarly, there is still the desire not to reveal weaknesses of a weapon system, in order to maintain its survivability. Nevertheless, while this is still a reason for secrecy, the question must be asked to which extent it is exaggerated.

Another reason for secrecy is the fear that the release of information might stir up diplomatic trouble, as is shown by the following quotation from the same report:

> "Inadvertently released information on deployments of nuclear weapons outside of the U.S. may violate international agreements and harm diplomatic ties with foreign host nations."

This quotation indicates that some host countries have an interest in secrecy on deployments on their soil. During the Cold War, Western local authorities had to deal with massive protests organised by the peace movement. It was in their interest to avoid provocations such as publications of deployments. Protests against deployments take place to this day. However, it is unlikely that their scale, which has become moderate, would be influenced by additional information on the deployments.[30] Host countries might also fear protests from other countries to which they are not allied.

3.1.3 Advantages of transparency and arms control benefits

Transparency of warhead stockpiles has important benefits.[31] It would give others a realistic image of capabilities. During the Cold War, the fear of a disarming first-strike attack was a major trigger of the nuclear arms race. Today, the secrecy of some, e.g. China, might lead to new arms build-ups by others, which, in turn, could create an obstacle to further reductions. Opacity in nuclear holdings still is an important basis of mutual suspicion that

29 U.S. Department of Energy, Office of Classified and Controlled Information Review, Eleventh Report on Inadvertent Releases of Restricted Data and Formerly Restricted Data under Executive Order 12958 (Deleted Version)(U), May 2003, http://www.fas.org/sgp/othergov/doe/inadvertent11.html

30 As an example, U.S. nuclear weapons are deployed in Germany at three locations: Ramstein, Büchel and Spangdalem, see W. M. Arkin, R. S. Norris, J. Handler, Taking Stock – World-wide Nuclear Deployments 1998, NRDC, Washington, D.C., 1998, p. 73, http://www.nrdc.org/nuclear/tkstock/tssum.asp#download. A group that organizes protests against nuclear weapons in general and their deployment in Germany specifically is "Gewaltfreie Aktion Atomwaffen Abschaffen (GAAA)" (Nonviolent action for the abolishment of atomic weapons), www.gaaa.org.

31 Fetter, op. cit. (fn. 26); see also Harald Müller, The Nuclear Weapons Register – A Good Idea Whose Time Has Come, PRIF Reports No. 51, June 1998.

could fuel new crises. Transparency of stockpiles would avoid unnecessary ambiguities and would contribute to the prevention of potential new arms races and competitions.

Transparency in nuclear warheads has been on the arms control agenda for several years: After the Cold War, the U.S. and Russia have engaged in a substantial nuclear arms reduction process, notably with the two START Treaties,[32] although currently, with the conclusion of the Strategic Offensive Reductions Treaty (SORT), the process seems to have come to a halt. In contrast to START and START II – neither of which entered into force – SORT does not provide for any transparency or verification measures.[33] Nevertheless, if the disarmament process is to be revived, transparency of warhead stocks would constitute an indispensable prerequisite. A transparency regime could start with the level of bilateral declarations between two sides, and finally end with an official UN register of all nuclear warheads worldwide.[34]

A special concern is warheads that are not yet covered by any control regime, either in the active stockpile or in a deposit and that are ready for use e.g. tactical nuclear weapons. As long as no information on these stockpiles is available, the potential for mistrust is high. Any success in nuclear weapons reductions will go along with doubts as to whether the reductions are really meaningful or whether they merely constitute a shift of warheads to other locations where they are not accounted for.

3.1.4 Overview on the current situation

In contrast to the transparency in strategic nuclear weapons that has been created between the two superpowers by these arms control treaties, transparency in tactical nuclear weapons – an entire category of nuclear weapons – is still lacking. They are only subject to an informal regime created by unilateral declarations by George Bush and Mikhail Gorbachov in the autumn of 1991. Since then, both sides have substantially reduced their tactical arsenals, but information exchange was limited to periodic updates on progress. There was no monitoring or any other meaningful transparency measures. Neither side has given a comprehensive overview on their tactical arsenals.[35] In addition, weapons in various reserve categories are completely omitted from official accounts.

The U.S. supplies by far the most detailed information about its nuclear weapons, although officially it does not acknowledge deployment locations or numbers of warheads. However, as an outcome of the Openness Initiative, it has released an official account of the total number of nuclear warheads in its stockpile up to 1961, the number of warheads retired or dismantled up to 1994, the number assembled each year, and some additional

32 Treaty text: http://www.fas.org/nuke/control/start1/text/. A summary is: A START Briefing Book, The Bulletin of the Atomic Scientists, November 1991, p. 24.

33 The U.S. Government is currently not inclined to engage in an arms control or reduction process that creates binding obligations for itself, Müller/Schaper, op. cit. (fn. 9).

34 Müller op. cit. (fn. 31).

35 William C. Potter, Nicolai Sokov, Harald Müller and Annette Schaper, Tactical Nuclear Weapons – Options for Control, UNIDIR Research Report, Geneva, 2000.

information.[36] Past stockpile numbers, which are partially composed of weapon systems still in the stockpile remain classified, and the release of any information that goes beyond this document is deemed to be harmful to national security.

However, independent observers are able to collect quite comprehensive and unambiguous lists of warhead-related data from information in the public domain.[37] For weapons locations and information, they monitor well known certified units and deployments of delivery vehicles, government publications and announcements, documents released under the Freedom of Information Act, Congressional hearings, reports by the U.S. General Accounting Office (GAO) and other independent agencies, and other publications, such as those by Jane's Information Group.[38] The U.S. government neither confirms nor denies these reports, but the authors claim that their sources can be traced to government.

It is much more difficult to obtain specific information on the Russian arsenal. Although the Russian government is more open than the former Soviet government was, there is no comparable disclosure of information related to warheads. Organisations like the NRDC that collect this information cite U.S. intelligence reports, Foreign Broadcast Information Service (FBIS) publications, publications of independent Russian researchers, and information flows. Independent Russian researchers have started to collect information on strategic nuclear weapons and to publish them.[39] Only a few sources originate from the Russian government, in contrast to the U.S.[40] Therefore, the collecting or-

36 Department of Energy, Declassification of Certain Characteristics of the United States Nuclear Weapon Stockpile, http://www.osti.gov/html/osti/opennet/document/press/pc26.html, as of December 2003.

37 Examples of organizations that collect and publish public domain information on nuclear weapons are the Natural Ressources Defense Council (NRDC), the Federation of American Scientists (FAS), the Center for Defense Information (CDI), and individuals. Examples of such documentations are: W. M. Arkin et al., Taking Stock op. cit. (fn. 30); NRDC Nuclear Notebook prepared by Robert S. Norris and William Arkin of the Natural Resources Defense Council, published in The Bulletin of the Atomic Scientists, http://www.thebulletin.org/issues/nukenotes/nukenote.html; Chuck Hansen, Swords of Armageddon, Chukelea Publications, Sunnyvale, 1995; The High Energy Weapons Archive, http://nuclear weaponarchive.org/, until May 2002 also hosted by FAS; Center for Defense Information (CDI), http://www.cdi.org/issues/nukef&f/database/usnukes.html.

38 Taking Stock, op. cit. (fn. 30), p. 4..

39 See website of the Center for Arms Control, Energy and Environmental Studies at the Moscow Institute of Physics and Technology (MIPT): Current Status and Future of Russian Strategic Forces, http://www.arms control.ru/start/rsf_now.htm, 2002; Pavel Podvig (ed.), Russian Strategic Nuclear Forces, The MIT Press, 2002.

40 Most of them are quotes and articles in the Russian press or articles by government members. An example is Alexei Arbatov, Deep Cuts and De-alerting: A Russian Perspective, in H. A. Feiveson (ed.), The Nuclear Turning Point — A Blueprint for Deep Cuts and De-Alerting of Nuclear Weapons, Washington DC: Brookings Institution, 1999, p. 320: "Whereas in 1991 the USSR had about 22,000 tactical nuclear weapons, at present Russia retains around 3,00, including 200 atomic demolition munitions, 600 air defense missile warheads, 1,000 gravity bombs and short-range air-to-surface missiles, and 2,000 naval anti-ship, antisubmarine, and land-attack weapons." Arbatov was a member of the State Duma of the Russian Federation Defense Committee. Other authors have published somewhat differing numbers, quoted in Potter, op. cit. (fn.. 35), p. 60.

ganisations caution that the published information is nowhere near as precise as the U.S. estimates.[41] The least precise is the information on the non-strategic nuclear forces.

The British Defence Ministry has published some information on warhead numbers and their operational status.[42] France has published figures, although in a less visible way via presidential speeches and legal documents attached to procurement laws and defence budgets.[43] Those NGOs that collect and publish this data claim that they collect bits of information about nuclear forces from numerous official publications, and use the monitoring of nuclear storage sites by peace organisations.[44] In Britain and France the locations are fairly well known, and the number of useful official publications quite numerous. China provides almost nothing officially,[45] the only sources of independent groups are U.S. government intelligence reports and the Taiwanese press.

The nuclear weapon possessing states that are not party to the NPT remain opaque. Through explosive testing India and Pakistan have spectacularly demonstrated the fact that they possess nuclear warheads, but do not reveal much further information. Israel neither confirms nor denies even the possession of nuclear weapons. India officially announces yields of warheads, but no numbers. It is also unknown, whether the warheads can be fitted to Indian delivery systems.[46]

Some of the information has been published on purpose, but on a low ranking governmental level e. g. in attachments to military procurement funding requests, in public comments of low ranking governmental officials, or even leaked to the press or researchers on an unattributable basis. This is the most informal way of creating transparency to a broader audience. There are many variations how transparency of stockpile numbers could be created. Other means are declarations by higher-ranking officials, invitations to site visits, or verification measures, the intrusiveness of which can vary over a wide range. One example of a more binding commitment is a nuclear weapon register. However, this has yet to prove acceptable to any of the NWPS. This was illustrated in 1993, when the NWS unanimously rejected a proposal by the German Foreign Minister Klaus Kinkel for a nuclear weapon register with the UN.[47]

41 Taking stock, op cit (fn. 37), p. 5.

42 British Ministry of Defence, What do you know about Nuclear Deterrence, http://www.mod.uk/ aboutus/keyfacts/factfiles/nuclear.htm, 7th January 2003: "We'll maintain fewer than 200 operationally available nuclear warheads."

43 Grand, op. cit. (fn. 12); an independent group that publishes data is the Centre de Documentation et de Recherche sur la Paix et les Conflits (CDRPC) that has published data on the French arsenal on its web site: Observatoire des armes nucléaires françaises, http://www.obsarm.org/main/obsnuc_cdrpc.htm

44 Taking stock, op. cit. (fn. 37), p. 5.

45 Li Bin, op.cit. (fn. 28).

46 There are open sources on these countries' potential delivery systems, e.g. see the Center for Defense Information's website http://www.cdiorg.

47 Klaus Kinkel, "German 10-point initiative for nuclear nonproliferation", Bonn, 15 December 1993. For the significance of this proposal and the reaction of the NWS see: Müller, op. cit. (fn. 26).

More information has become known than the governments are willing to publish. Some of it has become known by means of intelligence gathering or "national technical means" (NTM), as it is paraphrased in arms control. Walker emphasises that this "involuntary transparency" that renders the activities and intentions of an opponent transparent was a source of persistent friction between the two superpowers during the Cold War. Nevertheless, it also served the function of creating a little bit of confidence.[48]

3.1.5 Approaching a demarcation line

The reflections of this chapter on information on nuclear warhead arsenals and deployments are summarised in Table 1 of Appendix A. They are also compared to U.S. declassification (as this is the most open and advanced). The ideal demarcation takes into account proliferation risks, but only the most apparent "national security" concerns, e.g. deterrence. In case of nuclear warhead arsenals and deployments, there are hardly any proliferation risks. Transparency on all deployments would pose risks in relation to deterrence strategies. The ideal demarcation, therefore, recommends that almost all information be declassified.

3.2 Technical information on nuclear warheads

3.2.1 Types of information

Verification measures also apply to the technical details of individual warheads. They seek to distinguish between a real and a fake warhead and its identification. Therefore, verification must explore technical properties to a certain extent of intrusiveness in order to give an answer with some degree of assurance. But most of these technical properties are classified. It would not be necessary to learn all technical details of a specific warhead; the verification tasks could be accomplished with a subset of this information. Of course, the verification task becomes more difficult the less information can be obtained. On the other hand, proliferation dangers rise the more information becomes available.

Examples of technical information on warheads are: their mass and shape, the isotopic and chemical composition, the size of a pit and of its reflector, the types and shapes of conventional explosives and other components, the mass, shape and design of secondaries, or information on other components such as ignition electronics or the outer casing.

3.2.2 Reasons for secrecy

The major reason for secrecy is non-proliferation. Where specific technical warhead-related information becomes known, there is the risk that it could assist proliferators in their acquisition programs.

48 William Walker, Reflections on transparency and international security, in: Zarimpas (ed.), op. cit. (fn. 12), p. 15.

However, this specific warhead-related information must not be confused with the basic principles of nuclear weapons, which are publicly known. A lot of this information was declassified decades ago,[49] other information has been speculated about for years, and there is a relatively clear picture on the basic physics already in the public domain. Not only are the principles of nuclear weapons identified, the fundamental theories are also published in detail and are, to some extent, even available on the Internet.[50] Academics without access to or not making use of classified literature normally use fictitious simple models for investigating various aspects of the subject, e.g. for studying nuclear weapon effects,[51] simulating verification experiments,[52] or assessing proliferation dangers.[53] These publications are not officially authorised and, in some details, might contain mistakes. However, they are based on information that has been declassified and that can be used to reveal and understand the physical facts.

In contrast to the basic physics and simple models, information on quantitative technical details is not available because it is highly "proliferation relevant". It would be useful for proliferators because there are many laborious steps between a basic understanding of the operating principles and an actual technical blueprint. Proliferators would not only need to develop a theoretical model, they would also have to run computer simulations of the implosion of pits, the build-up of a nuclear chain reaction, the release, transformation and spread of energy, the heating and expansion of the plasma, and the mutual effects of these different physical mechanisms on each other. These computer programs must be fed by data that are not available from the open literature.[54] They must also *inter alia* – experimentally explore several physical and mechanical properties of metallic nuclear materials and the art of generating spherical implosions without instabilities, measure their performance with flash x-ray machines, or develop special high power short-time elec-

49 E.g. Robert Serber, The Los Alamos Primer, University of California Press, Berkeley 1992, whose contents have been declassified in 1965.

50 Cf. op. cit. (fn. 5).

51 Locke, op. cit. (fn. 5).

52 Steve Fetter, Thomas B. Cochran, Lee Grodzins, Harvey L. Lynch, Martin S. Zucker, Measurements of Gamma Rays from a Soviet Cruise Missile, in: in: Frank v. Hippel, R. Z. Sagdeev, Reversing the Arms Race — How to Achieve and Verify Deep Reductions in the Nuclear Arsenals, New York 1990, p. 379; S. T. Belyaev, V. I. Lebedev, B. A. Obinyakov, M. V. Zemlyakov, V. A. Ryazantsev, V. M. Armashov, S. A. Voshchinin, The Use of Helicopter-borne Neutron Detectors to Detect Nuclear Warheads in the USSR-US Black Sea Experiment, in the same volume, p. 399; W. Rosenstock, A. Tüchsen, T. Köble, G. Krzinski, M. Jeske, A. Herzig, J. Peter, Aufbau einer transportablen Detektoranordnung zur Verifikation von A-Waffen (Construction of a transportable detector for the verification of atomic weapons), Report INT 169, Euskirchen, April 1997.

53 Peter Hafner, Improvisierte Nuklearwaffen – Herstellung einfacher Nuklearwaffen durch terroristische Gruppen? (Improvised nuclear weapons – construction of simple nuclear weapons by terrorist groups?), Report INT 175, Euskirchen, Germany May 2003; Alexander Kelle, Annette Schaper: Terrorism using biological and nuclear weapons: A critical analysis of risks after 11 September 2001, PRIF Reports, No. 64, 2003; A. Schaper, Arms Control at the Stage of Research and Development? – The Case of Inertial Confinement Fusion, Science & Global Security, Vol. 2, p. 1-22, 1991. The latter uses a simple model of a thermonuclear weapon.

54 Examples are equations of state or opacities of hot, dense heavy metal plasmas.

tronics. These tasks are not insurmountable and can be accomplished by ‘medium developed’ states within a couple of years. Nevertheless, the task would be easier and quicker if certain technical details became known to proliferators beforehand.

However, the information that is useful to a proliferator's program and the information that is useful for warhead verification is not necessarily the same. It is only partly overlapping, and some of it can be deduced. An example of proliferation-relevant information is the chemical composition of pit material. This is because small amounts of alloys can alter the physical properties of the pit metal and as a consequence, this would facilitate its machining, affect its phase stability or its corrosiveness. An example of this is plutonium, the crystalline phase of which is stabilised by small amounts of gallium. Details of this information could spare many experiments with the nuclear weapon metal. Another example is details of the arrangement of the conventional explosives, the proliferation relevance of which is clear. Similarly, it may be speculated whether special materials for the reflector could be used that are more efficient than those cited in the open literature, or whether there are special technologies for the boosting mechanism e.g. the insertion of a deuterium-tritium mix into a pit that will produce additional neutrons when heated and compressed by a nuclear fission explosion. This kind of information may be revealed during intrusive verification. However, a proliferator might also be able to invent such mechanisms by himself. Nevertheless, secrecy of this information is well advised in order to delay proliferation. But it must be kept in mind that – similar to export controls –while it can create additional obstacles to a proliferator, it is not a principal barrier that cannot be overcome.

Other information might not be useful for “beginner” proliferators because their first step would be to make a simple but reliable device, not a sophisticated one. But it would be useful for other nuclear weapon states or proliferators who have already tested their first simple devices and who seek to further optimise their systems. Examples of such optimisation are warheads with a high yield-to-weight ratio, with a highly efficient use of nuclear materials, with yield selection capabilities, or with special safety and security features e.g. one-point-safety[55] or permissive action links (PAL).[56] Also, the functioning of thermonuclear weapons is classified, as it may be useful in a more advanced program. More specifically, the engineering details of a thermonuclear weapon are secret, in contrast to its basic physics but similarly to fission warheads.[57] An example of a state that is probably very interested in technical information on thermonuclear weapons is India.

55 “One-point safety” is the reduction of the probability of an accidental detonation because of an unintended shock wave in the conventional explosive surrounding the fissile material.

56 A “permissive action link” (PAL) is an electronic lock attached to a weapon that prevents its unauthorised arming and ignition.

57 Most of the basic principles became known because of international research on inertial confinement fusion (ICF), whose basic physics is the same. It has first been published by international researchers and declassified by the U.S. in the early 90ies. Early examples of publications on the ignition mechanism are Jürgen Meyer-ter-Vehn, On Energy Gain of Fusion Targets: The Model of Kidder and Bodner Improved, Nuclear Fusion, Vol. 22, p. 561, 1982; Jürgen Meyer-ter-Vehn, Zur Physik des Fusionspellets (On the physics of the fusion pellet), Physikalische Blätter, Vol. 43, 1987, p. 424.

Owners want to protect the information on the technical details of sophisticated mechanisms in order to keep a competitive advantage and also to delay proliferation.

So far we have just considered information that reveals technical details of the construction of a nuclear warhead. There is an additional type of information i.e. information on the performance of a warhead. In other words, there are two types of information related to transparency in warhead dismantlement: type one reveals technical details of warhead construction and specials mechanisms. Type two reveals its capabilities, such as the quantitative results of its construction. An example of type one – construction information – is the method of how to achieve a high efficiency of the nuclear fuel, whereas the efficiency of a warhead itself e.g. the fraction of the fuel that is fissioned, belongs to type two – performance information. As another example, the information relating to how to achieve a high yield-to-weight ratio belongs to type one, whereas the quantities of yield-to-weight ratios of specific warheads belong to type two. Type one information is highly proliferation relevant, whereas type two information is not necessarily so. It is unlikely that all information on specific abilities of warheads can be used to deduce construction details, although there might be certain exceptions. It is also possible that a combination of such information could be used to draw conclusions on a specific construction detail.[58] In decision-making on declassification of specific information, in each case, its proliferation relevance must of course by scrutinised.

Nevertheless, today, owners want to protect not only the proliferation-relevant type one information on the technical details of special mechanisms, but also much of type two information. As a consequence, a lot more technical information on the warhead that may be useful for its identification during verification is secret too. It is unlikely that this secrecy can be explained only by proliferation concerns.

We may assume that there are additional reasons for secrecy on the performance and abilities of warheads, mainly of category two, e.g. “secrecy for national security” (cf. section 2.1.1). The owners may hesitate to reveal their technical abilities for various reasons: a technological superiority might motivate adversaries to engage in strengthened efforts to achieve similar capabilities. Some information might reveal technical vulnerabilities that an adversary might exploit, which would undermine deterrence. The Cold War tradition of surprising the enemy may also indirectly play a role. Although, as this motive becomes increasingly outdated for the more advanced nuclear weapon states, it may be better categorised as conservative inertia. It is also possible that perceived technical weaknesses should be hidden in order to avoid countermeasures, especially in scenarios involving

58 As an example: in 1989, Egbert Kankeleit has drawn a quantitative conclusion of the compression of the Pu fuel in the Nagasaki bomb, from a quotation by Oppenheimer that contained information on its pre-ignition probability. See: E. Kankeleit, C. Küppers, U. Imkeller, Bericht zur Waffentauglichkeit von Reaktorplutonium, Report IANUS-1/1989, this report has been translated by the Livermore Laboratory with the title “Report on the weapon usability of reactor-grade plutonium”. Later, Carson Mark has used the same reasoning in order to avoid the use of classified information, see: C. Mark: Explosive Properties of Reactor-Grade Plutonium, Science & Global Security, Vol. 4, p.111, 1993. However, although the compression achieved in the Nagasaki explosion is classified, it should also be regarded as type-2 information that is hardly proliferation relevant.

anti-ballistic missile (ABM) systems. In addition, we may speculate whether there are cases in which the owners want to hide technical weaknesses because they want to bluff the world to believe in greater technical prowess than is actually the case. An example is the Indian nuclear tests of May 1998. Although India claims to have detonated a thermonuclear weapon, this assertion must be doubted, and probably it was only a boosted fission explosion.[59]

3.2.3 Advantages of transparency and arms control benefits

In relation to warhead verification measures, transparency of some technical details will be needed because this would facilitate the process of identification. Warhead identification is crucial to the verification of warhead dismantlement. If assurance can be created that a sealed container holds a specific warhead type, all other verification measures will just need to confirm that accounted items and their seals have not been changed during transport and that the items have reached their declared destination e.g. an intermediate storage site or a dismantlement facility. Of course, verification of the materials exiting the dismantlement facility is also necessary (see section 3.3).

In any meaningful future nuclear disarmament, transparency of warhead dismantlement will play an important part. In the Joint Statement of Presidents Clinton and Yeltsin at the Helsinki Summit in March 1997, they stated that a START III Treaty should contain, among other things, "Measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads…".[60] So far, verification in nuclear arms control has covered mainly delivery systems, but has hardly affected warheads themselves. An exception is the INF Treaty, which required verification capable of distinguishing between banned SS-20 missiles from permitted SS-25 missiles. For this purpose, one verification measure was to measure fluxes of neutrons emitted from warheads for each type of missile system, whilst simultaneously shielding the warheads in order not to reveal too much information on their design.[61] The most recent nuclear arms control agreement – SORT – falls short of all expectations, as it does not include any verification at all.

The problem of the friction between transparency needs for warhead identification and secrecy for the protection of sensitive information has already been investigated dur-

59 The design of a thermonuclear weapon needs precise experimental data on the fist stage fission trigger, which can be obtained only by preceding nuclear tests, see A. Schaper, Bombenstimmung in Indien und Pakistan (Bomb mood in India and Pakistan), Spektrum der Wissenschaft (German edition of Scientific American), July 1998, p. 110. Seismologists have pointed out that the yield of the explosion was only a quarter of what the Indian government has announced which falls below a typical thermonuclear explosion, see: Terry C. Wallace, The May 1998 India and Pakistan Nuclear Tests, Seismological Research Letters, September/October 1998, pp.386-393.

60 President Clinton and President Yeltsin, Joint Statement on Parameters on Future Reductions in Nuclear Forces, White House Fact Sheet, Helsinki, 21 March 1997, printed in: Disarmament Diplomacy, April 1997, p. 32.

61 David Hafemeister, U.S. nuclear security cooperation with Russia and transparency, in: Zarimpas (ed.), op. cit. (fn. 12), p. 80

ing an experiment conducted by the U.S. Arms Control and Disarmament Agency (ACDA),[62] in which security personnel played the role of inspectors who tried to distinguish warheads from other objects. The experiment clearly showed a direct relation between the accuracy of the inspections results and the amount of classified information that had been released. Nevertheless, the study concluded that compromises are possible.

Measures relating to finding technical solutions to transparency problems have been investigated in detail by the U.S. and Russia since the mid-1990s. Their significance has increased, as it has become clear that both states are not prepared to exchange classified technical information.[63] To a certain extent, such technical solutions may help to bridge this lack of political will or legitimate concerns, but there are limitations.

The aim of these technical measures is to protect as much sensitive information as possible while at the same time to create the highest possible assurance that an object can be identified correctly, whether it contains a specific nuclear warhead or a decoy. At the heart of these measures is radiation measurement. All nuclear warheads contain fissile materials that emit gamma rays and neutrons, both spontaneously and when irradiated by external neutrons. The spectra of these radiations depend on the construction of the warhead e.g. the nuclear and non-nuclear materials and shapes of its components, and can be measured. Therefore, they can be used as its signature or "fingerprint". Methods of measurements of spontaneous radiation are called *passive* methods, measurements of spectra generated by external neutrons are called *active* methods. In principle, experts can draw a wealth of detailed information of the warhead construction from a spectrum. As an example, in July 1989, a joint Russian-U.S. experiment, the so-called "Black Sea Experiment", took place that aimed to detect a cruise missile warhead by passive methods.[64] Later, Tian Dongfeng, a Chinese nuclear weapon expert, demonstrated which information on the warhead could be deduced from the published "Black Sea" spectrum.[65] This information is remarkably detailed, and far too transparent, in the opinion of the Chinese author. A whole set of technical warhead characteristics can be deduced from a spectrum,

62 United States Arms Control and Disarmament Agency, Final Report – Volume I: Field Test FT-34. Demonstrated Destruction of Nuclear Weapons (U), January 1969, declassified in 1990. See also Frank von Hippel, The 1969 ACDA study on warhead dismantlement, Science & Global Security, Vol. 2, No. 1, 1990, p. 103.

63 Oleg Bukharin, Appendix 8A. Russian and US technology development in support of nuclear warhead and materrial transparency initiatives, in: Zarimpas (ed.), op. cit. (fn. 12), p. 165.

64 Steve Fetter, Thomas B. Cochran, Lee Grodzins, Harvey L. Lynch, Martin S. Zucker, Measurements of Gamma Rays from a Soviet Cruise Missile, in: F. v. Hippel, R. Z. Sagdeev, Reversing the Arms Race — How to Achieve and Verify Deep Reductions in the Nuclear Arsenals, New York 1990, p. 379; S. T. Belyaev, V. I. Lebedev, B. A. Obinyakov, M. V. Zemlyakov, V. A. Ryazantsev, V. M. Armashov, S. A. Voshchinin, The Use of Helicopter-borne Neutron Detectors to Detect Nuclear Warheads in the USSR-US Black Sea Experiment, in: v. Hippel/Sagdeev, p. 399.

65 Tian Dongfeng, Xie Dong, Liu Gongliang, High Energy Gamma-Ray "Fingerprint" – A Feasible Approach to Verify Nuclear Warhead, in: Institute of Applied Physics and Computational Mathematics, Program for Science and National Security Studies (Arms Control Collected Works), Beijing 1995., p. 63. The author suggests not to use the whole spectrum for warhead identification but just a small part of it. It would be sufficient and would protect other information.

for instance plutonium composition and age, some information on non-nuclear materials, and the presence of some other significant materials. It is also well suited for warhead identification in the context of detecting and identifying smuggled nuclear materials.[66]

Information protection techniques aim to shield spectra and other information and to provide not much more than a plain yes or no answer to the question whether an object is a specific warhead. The joint U.S.-Russian scientific groups have investigated mainly two approaches called "*templates*" and "*attributes*".[67] In the template methods, spectra are measured and compared to a reference spectrum that has been previously taken – the template. The measurement and its processing is protected by an "*information barrier*", e.g. closed devices involving computers without permanent memories that give out only the minimum information that the verification process needs.[68] However, it is disputed among experts whether this method does actually protect sensitive information, especially during template initialisation, and during template storage between inspections, since the template itself is a detailed spectrum and contains all the information that must be protected. In cases where both sides decide to share more information on nuclear warheads, these problems might be less severe. In order to avoid problems, they could share this information just between themselves.

A few years ago the interest shifted to another approach – the attribute methods. These also use radiation measurements, but no template. These measurements take place behind an information barrier and identify certain technical information i.e. the "*attributes*" that are unique for a specific warhead.[69] In relation to HEU, the identification of attributes is more difficult, but indirect methods are being discussed.[70] The attribute methods also need an information barrier but avoid the storage of sensitive data. Although they are easier to negotiate, therefore, they also pose severe problems.[71] First of all, both sides must accept common quantitative values and their deviations, which, on the one hand need to

66 W. Rosenstock/J. Schulze/A. Tüchsen/T. Köble/G. Kruzinski/G. Jaunich/J. Peter, M. Diedrichs, Entwicklung und Untersuchung von transportablen Meßsystemen zur Verifikation von Kernwaffen (Development and investigation of transportable measuring systems for the verification of nuclear weapons), INT-Bericht no. 162, Euskirchen, December 1995; W. Rosenstock/A. Tüchsen/T. Köble/G. Krzinski/M. Jeske/A. Herzig/J. Peter, Aufbau einer transportablen Detektoranordnung zur Verifikation von A-Waffen (Construction of a transportable detector device for the verification of nuclear weapons), INT-Bericht No. 169, Euskirchen, April 1997.

67 For details on templates and attributes, see Bukharin, op. cit. (fn. 63).

68 On information barriers, see Bukharin, op. cit. (fn. 63), and J. L. Fuller, Information barriers, INMM Proceedings, op. cit. (fn. 2).

69 In case of plutonium, passive methods are sufficient. Examples for attributes are: the isotopic composition, the Pu mass, the absence of oxide, the age of the Pu and the symmetry of the radiation, see. Bukharin, op. cit. (fn. 63). For more details see: T. R. Rutherford, J. H. McNeilly, Measurements on material to be stored at the Mayak fissile material storage facility, INMM Proceedings, op. cit. (fn. 2).

70 Researchers focus on methods to detect U-232, which is present in re-enriched uranium that has previously been irradiated in a reactor. However, it is not clear whether all HEU warheads contain re-enriched materials, Bukharin, op. cit. (fn. 63). For more details see: T. B. Gosnell, INMM Proceedings, op. cit. (fn. 2).

71 Bukharin, op. cit. (fn. 63).

be meaningful, but on the other do not reveal sensitive information. Secondly, it is not clear how to resolve an anomalous situation. The more information remains secret, the more difficult this approach becomes.

In sum, both approaches for warhead identification focus on technical solutions to the problem of secrecy. Nevertheless, both become the more difficult to devise and to negotiate, the less information that is released. The solution is not to work on better information barriers. Instead, the problem is inherent, because either a template must be used and intermediately stored (containing plenty of secret reference information), or alternatively, quantitative values of attributes, for example of warhead characteristics, must be commonly accepted and exchanged. The latter would avoid the storage of data but would require the shared use and exchange of certain secrets as a prerequisite. At the heart of the problem is the extensive secrecy on all pieces of information that can serve as attributes for warhead identification.

Transparency of technical information is the prerequisite for any verification related to warheads, whether in respect of storage or dismantlement, or identification of components. This is its major potential arms control benefit.

3.2.4 Overview on the current situation

Once again, the highest degree of openness and effort can be observed in the U.S. At the end of 1993, as part of its Openness Initiative, the U.S. DoE declassified and published a large amount of technical information on nuclear warheads. In line with newly developed criteria, this information was regarded as no longer posing a proliferation or security threat, and there was no danger of an undesirable disclosure of America's own technological state of development. It is published in the RDD lists.[72] However, in the last year a reversal of this trend can be observed.[73] An indication is the scandal about alleged Chinese spying on U.S. nuclear weapons. A Congressional report (Cox-Report[74]) on the allegation resulted in calls for more secrecy and less international collaboration, although it has been criticised by some for containing many mistakes and for causing a degree of hysteria.[75]

Russia is far less transparent. The extent of nuclear secrecy that still exists in Russia goes far beyond the requirements for non-proliferation and national security.[76] A variety

72 RDD-7, see op. cit. (fn. 23).

73 Bush Administration Documents on Secrecy Policy are being compiled by Steven Aftergood and made available at: http://www.fas.org/sgp/bush/index.html.

74 Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China, Congressional Report, Mai 25, 1999, available at http://www.house.gov/coxreport/.

75 A Richard L. Garwin and Wolfgang K.H. Panofsky, Nuclear Secrets: Rush to Judgment Against China, International Herald Tribune Tuesday, August 3, 1999. A quotation from this article is: "Each of us has a right to make up his or her own mind, but not to make up his or her own facts. Yet that seems to be happening on the nuclear threat from China." See also Richard L. Garwin, Why China Won't Build U.S. Warheads, Arms Control Today April/May 1999.

76 Oleg Bukharin and Kenneth Luongo, U.S.-Russian Warhead Dismantlement Transparency: The Status, Problems, and Proposals, PU/CEES Report No. 314, April 1999.

of bilateral informal U.S.-Russian transparency commitments have been initiated in the 1990s but have never been fulfilled.[77] Note should be taken of the attempt to sign an Agreement of Cooperation between Russia and the U.S. permitting the sharing of classified information that was then stopped by Russia in 1995. In January 1994, Presidents Clinton and Yeltsin agreed on establishing a working group on transparency and irreversibility of nuclear reductions, but it has never been implemented. In March 1994, both sides agreed on inspections of fissile materials from dismantled weapons. Again, these inspections have never been implemented. In May 1995, both presidents issued a statement on safeguards, transparency, and irreversibility reaffirming their commitments and agreed to have experts investigate details. The aim was to conclude an agreement for co-operation that would allow the parties to exchange sensitive information. These talks were terminated by the Russian side without explanation.[78] Apparently, too much information was involved that the Russians deemed too sensitive to be shared even on the bilateral level with another NWS.

In Spring 2000, the British Government published a study on nuclear transparency and verification.[79] It can be regarded as remarkable progress in comparison to previous opacity. Nevertheless, it still falls behind U.S. efforts. It provides details of how to verify nuclear disarmament and the dismantling of warheads, but still lacks elaborate technical declassification.

Initiatives comparable to those in the U.S. and Britain are absent in France. So far, no declassification or transparency campaign exists. China's interest in nuclear arms control has grown during the last years. However, all publications are based on foreign sources, and information on Chinese nuclear weapons additional to what is already published elsewhere does not exist. There are no transparency initiatives comparable to those in the U.S. and Britain. While Chinese experts are interested in the topic of verification of warhead dismantlement, they are very cautious about the degree of necessary intrusiveness.[80] The other nuclear weapon possessing states – India, Pakistan, and Israel – also lack transparency of their nuclear complexes.

3.2.5 Approaching a demarcation line

A summary of the preceding deliberations is contained in Table 2 (Appendix A). A demarcation that tries to minimise proliferation risks, while at the same time facilitates veri-

77 Matthew Bunn, The next Wave: Urgently needed new steps to control warheads and fissile material, Report Carnegie Endowment for International Peace and Harvard University, March 2000, available at www.ksg.harvard.edu/bcsia/atom, p. 47.

78 Steve Fetter, A Comprehensive Transparency Regime for Warheads and Fissile Materials, Arms Control Today, January/February 1999.

79 Atomic Weapons Establishment, Confidence, Security and Verification: The challenge of global nuclear weapons arms control, AWE/TR/2000/001, in the internet at http://www.mod.uk. For a short critique see Annette Schaper with Trevor Findlay, Confidence, Security & Verification, Trust & Verify, No. 92, July 2000.

80 See op. cit. (fn. 65).

fication of nuclear warheads and nuclear disarmament, must make compromises. The efforts of the U.S. Openness Initiative have resulted in a remarkable set of declassification. It is characterised mainly by protecting quantitative and specific information that would accelerate a proliferator's program while declassifying more general scientific information. In respect of technical information on nuclear warheads, in a first approximation it makes sense to adopt the U.S. model as the ideal demarcation line that will serve as reference for further research.

3.3 Transparency of fissile material stocks and production facilities

3.3.1 Types of information

The dismantlement of nuclear warheads generates nuclear and non-nuclear warhead components and fissile materials. Dismantlement of warheads takes place not only as a result of nuclear disarmament, remanufacturing is also a part of the maintenance process of an arsenal. Therefore, nuclear weapon possessors maintain reservoirs and pipelines of fissile materials and components for nuclear warheads, in addition to their warheads in deployment and reserve. These materials constitute an additional reserve for potential rearmament. Transparency of warheads would be incomplete if it was not supplemented by transparency in fissile material stocks.

Relevant information comprises: quantities of weapon plutonium and HEU, broken down in the political categories "reserve material", "remanufacturing pipelines", or "still in military jurisdiction but considered excess to weapons needs"; the same quantities broken down in technical categories such as isotopics, chemical composition, physical shapes e.g. pits, recast metal objects, oxide powder, or scraps and residues, and broken down in locations e.g. at storage and manufacturing sites or in various disposition processes; information on additional civilian stocks and HEU for naval propulsion, an overview on all production capabilities e.g. reprocessing and enrichment, also reactors, fuel fabrication facilities and other elements of the nuclear fuel cycle. Documentation of production history might add to a clearer picture.

Finally, in this context the weapons usability of special and other materials is also interesting, and the technical explanations why. Examples are the weapons usability of reactor-grade plutonium, special HEU fuels for civilian research reactors, or other isotopes arising in civilian nuclear fuel cycles and posing potential proliferation dangers, especially neptunium-237 (Np-237) and americium-241 (Am-241).

3.3.2 Reasons for secrecy

Reasons for keeping these miscellaneous types of information secret vary. In respect of the technical properties of warhead components, it is obvious that the reasons are the same as for secrecy on technical details of complete warheads (subsection 3.2.2). Warhead components would in principle reveal the same information as complete warheads. The major motives are non-proliferation and national security.

As in the case of information arising during warhead dismantlement, there are similarly many secrets on fissile materials. An example is the isotopic composition of weapons plutonium. In the U.S. the isotopic composition is classified as long as the material is in warhead component form. As soon as this form is modified, the isotopic composition can be revealed.[81] In contrast, in Russia the isotopic composition of disarmament material remains classified as well. Were this information to be revealed, no additional proliferation danger would be created, because it is already generally known that nuclear weapon possessors prefer a high Pu-239 content for their weapons plutonium and a high U-235 content for their weapons uranium. It is a matter of speculation as to whether the secrecy is simply the result of an untouched tradition. Perhaps it is borne of a fear that surprises could be revealed; either that the composition has an embarrassingly low quality, or even the contrary, that plutonium has been further enriched.[82] The isotopic composition offers some more conclusions. In the case of plutonium, it is possible to deduce the age of the material, due to the build-up of americium as a consequence of decay processes. When the americium exceeds a certain threshold the crystal structure of the plutonium changes. This affects the density and the shape of the pit. Consequently, these pits are regularly remanufactured. The isotopics may reveal information on the production history of the plutonium, for instance, whether it is re-reprocessed, perhaps by having its americium removed, or whether it is simply diluted. Together with other information such as reactor operating times, it may then be possible to deduce even more information, for example, on total quantities of materials produced.

The question remains why this deducible information remains secret. It may be assumed that motives for secrecy on quantities are the same as motives for secrecy on warhead numbers. Fissile material quantities, even more so the breakdowns described above, would reveal the potential for rearmament. Nevertheless, rough estimates and the resultant rearmament potential have been collected and published by non-governmental experts.[83] Official and more precise numbers would not principally change the picture, at least in the case of the established nuclear weapon states. In the case of India, Pakistan, and Israel, the numbers are lower and the estimates less accurate, so that the revelation of

81 J.T. Markin, W.D. Stanbro, Policy and technical issues for international safeguards in nuclear weapon states, in: International Nuclear Safeguards 1994, Proceedings of a Symposium, Vienna, 14-18 March 1994, Vol. II, p. 639. See also: U.S. DoE, RDD-7, op. cit. (fn. 23).

82 Indications in this direction can be seen in the Tengen smuggling case: In 1994, a smuggled sample of Pu from Russia was detected in Tengen (Germany) that originated in Russia and apparently has been enriched in Pu-239 with centrifuges. Its isotopic composition was: 0,067% Pu-238, 99,75% Pu-239, 0,18% Pu-240, 0,003% Pu-241, 0,0002 Pu-242. Since Russian warheads are said to be constructed in a way that does not take into account later dismantling, it might be assumed that some Russian warheads consist of enriched plutonium. Plutonium of such a low content of higher isotopes has a very slow americium build-up and does not need to be remanufactured. However, enrichment of plutonium is technically very difficult and costly.

83 David Albright, Frans Berkhout, William Walker, Plutonium and Highly Enriched Uranium 1996 – World Inventories, Capabilities and Policies, SIPRI (Oxford University Press), 1997. For updates, see also the website of the Institute of Science and International Security (ISIS): http://www.isis-online.org; David Wright, Lisbeth Gronlund, Estimating China's Production of Plutonium for Weapons, Science & Global Security, Vol. 11, 2003, pp. 61-80.

such numbers might indeed refine estimates of their nuclear armament potential. Hence, these states probably consider such transparency not to be in their security interests. But most of the established nuclear weapon states are not interested in disclosing too many details on their existing fissile material stocks either.[84]

Another motive might be the fear that transparency on fissile materials could reveal too many embarrassing details on previous inaccurate accounting. Russia especially has been the subject of great concern for many years, with regard to the security of nuclear material. It seems that an exact overview of stocks has either been lost or never existed in a sufficiently accurate form. Many plants and deposits are not satisfactorily secure. But it is also unclear whether similar problems exist in other nuclear weapon possessing states. Even in the US, complaints about the limited security surrounding weapon-ready material have repeatedly been filed, even though much stricter and more modern regulations concerning the physical protection of nuclear material are in place.[85] Transparency on fissile material stocks would reveal such deficiencies, although the question remains whether this really is one of the reasons for secrecy. The situation in Russia is already quite well known and also openly addressed by the Russian government, mainly in the context of cooperation threat reduction (CTR) efforts. In the U.S., within the Openness Initiative, there are indications that such motives for secrecy are unacceptable, at least in principle.

A final potential motive for secrecy can be simple conservative inertia. In NWPS, the assumption prevails that fissile materials just like nuclear weapons are national property and of no concern to the international community. In contrast to NNWS who have a tradition of international safeguards on their nuclear fuel cycles and who are undergoing even more transparency and verification obligations, the civilian nuclear fuel cycles in NWPS remain under national custody.[86] As long as this remains the case, any obligation of transparency in the military fuel cycle is probably even less imaginable.[87] Regular and comprehensive transparency measures, even when voluntary, might be regarded as a slippery slope towards binding obligations and unwanted verification measures.

3.3.3 Advantages of transparency and arms control benefits

Transparency in fissile materials has many benefits. First of all, it would complement transparency on warhead stocks and would give a realistic picture of the current situation of nuclear armament. Transparency in fissile materials, especially on those from or for nuclear weapons, would create international confidence that the nuclear disarmament process is taking place as declared. The more secrets that are abandoned and the more

84 Cf. section: 3.3.4 Overview on the current situation.

85 President's Foreign Intelligence Advisory Board, Science At Its Best, Security At Its Worst: A Report on Security Problems at the Department of Energy (the Rudman Report), Washington, DC: President's Foreign Intelligence Advisory Board, June 1999, http://www.fas.org/sgp/library/pfiab/.

86 An exception is the civilian nuclear fuel cycles of Britain and France that are subject to Euratom safeguards.

87 A. Schaper, The Case for Universal Full Scope Safeguards on Nuclear Material, The Nonproliferation Review, Vol. 5, No 2, Winter 1998, p. 69.

information that is declared, the more the overall picture becomes complete and convincing. Initial voluntary declarations could pave the way for binding commitments, for example, through the establishment of an international register of fissile materials and production capabilities.[88] The register could be based at the International Atomic Energy Agency (IAEA), constituting a foundation upon which future international verification could be built.[89] This would create a level of transparency similar to that already provided by the NNWS. Although the IAEA does not publish quantitative figures it does certify whether obligations are met. The international safeguards in the NNWS have greatly reduced the danger of nuclear proliferation. They have triggered discipline and high standards of physical protection, material accountancy and control of nuclear materials and installations. The major dangers now result from the lack of similar standards in NWS. Universal international safeguards would promote a security culture and similarly high standards everywhere.[90]

Secondly, transparency in fissile materials would be a prerequisite for efforts to stem nuclear proliferation. Major sources of proliferation-relevant materials and technologies can be found in NWS, which control them through solely national means, without obligation to adhere to international standards or to have the security of their nuclear materials checked by an international agency. The proliferation dangers have increased since the end of the Cold War because of the large quantities of weapon materials that are becoming surplus to requirements. The processes of warhead dismantlement, material transport, storage, and disposition create additional diversion risks. The risks are especially high in Russia, which is in the process of transforming its nuclear control system. The security of the Russian nuclear production complex is estimated to be far below Western standards and in danger of deteriorating even further. Incomplete accounting records from the Soviet period make it almost impossible to determine whether fissile materials could already have been illicitly removed.[91]

A variety of co-operation projects between Russia and other states, notably the U.S., are aimed at enhancing the security of fissile materials and warheads. Transparency in fissile materials would facilitate international cooperation to improve the situation, for example, in respect of international collaboration in material protection, control and ac-

88 See Albright, Berkhout, Walker, fn. 83, especially pp. 6–8 and chapter 15. In his proposal of a nuclear weapon register, H. Müller incorporates also a fissile material register, see op. cit. (fn. 26).

89 On the trilateral initiative see next section (3.3.4 Overview on the current situation).

90 Schaper, op. cit. (fn. 87).

91 There are numerous publications on the situation and the security of the Russian nuclear complex and the international response to it. See for example Bunn, fn. 77; Kevin O'Neill, The Risk of Theft: Protecting Fissile Materials in the Former Soviet Union, in: David Albright and Kevin O'Neill (ed.), the Challenges of Fissile Material Control, Washington, DC, 1999, p. 41, downloadable at: www.isis-online.org; Vladimir A. Orlov, "Accounting, Control, and Physical Protection of Fissile Materials and Nuclear Weapons in The Russian Federation: Current Situation and Main Concerns", Paper presented at the International Seminar on MPC&A in Russia and NIS, Bonn, sponsored by the Deutsche Gesellschaft für Auswärtige Politik, April 7-8, 1997. For European activities see Kathrin Höhl, Harald Müller and Annette Schaper, Edited by Burkard Schmitt, EU cooperative threat reduction activities in Russia, Chaillot Paper 61 – June 2003, http://www.iss-eu.org/chaillot/chai61e.html.

countancy (MPC&A) measures for storage and transportation. Controls aimed at ensuring that funds are being spent properly sometimes conflict with secrecy on fissile materials and facilities.[92] As an example, an achievement of U.S.-Russian CTR cooperation is the construction of a storage facility for excess weapons materials and warhead components. However, the U.S. wants to ensure that the materials stored at the facility are indeed of weapons origin. But the Russian side refuses to grant sufficient transparency, not only because of its own secrecy requirements but also because the U.S. refuses to offer reciprocal transparency at corresponding sites of its own. The more secrets are released the easier it becomes to incorporate excess nuclear weapon materials into international CTR activities.

Thirdly, transparency in fissile materials would facilitate technical disarmament measures, for example, in the disposition of plutonium and HEU from dismantled weapons. For several years, the problem of how to dispose of excess weapons plutonium in a way that minimises proliferation dangers and maximises the technical hurdles for rearmament have been studied, nationally and internationally.[93] Studies dealing with Russian material always have to cope with the problem that the material is still tainted with so many secrets. In the studies on the disposition option of fabrication mixed oxide fuel (MOX) from excess weapons plutonium, the isotopic composition or the plutonium is still secret and must therefore be replaced by fictitious assumptions.[94] But for the design of a MOX facility, this information is needed in order to calculate its criticality and to design the elements of the facility accordingly.

In September 2000, the U.S. and Russia concluded an agreement on the disposition of excess weapons plutonium, the "*Plutonium Management and Disposition Agreement*" (PMDA).[95] This agreement focuses mainly on the MOX option. It devotes large sections to

92 See O'Neill, op. cit. (fn. 91).

93 Prominent examples for studies are: U.S. National Academy of Sciences: National Academy of Sciences (NAS), Committee on International Security and Arms Control (CISAC), Management and Disposition of Excess Weapons Plutonium, Washington 1994; NAS, CISAC, Management and Disposition of Excess Weapons Plutonium: Reactor Related Options, Washington 1995. A German – French – Russian project for the building of a MOX pilot plant for Russian disarmament plutonium and an American – Russian agreement on the non-military use of Russian disarmament uranium had been among the most advanced plans until the German Government cancelled its support because of domestic political reasons. See Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH, Siemens Aktiengesellschaft und Ministerium für Atomenergie der Russischen Föderation (MINATOM): Basisauslegung für eine Pilotanlage zur Produktion von Uran-Plutonium-Brennstoff aus waffengrädigem Plutonium und zum Einsatz dieses Brennstoffs in Kernreaktoren (Principal design of a pilot plant for the production of uranium plutonium fuel from weapon grade plutonium and for the use of this fuel in nuclear reactors), Final Report, 28.02.1997. See also N.N. Yegorov et al. The AIDA-MOX 1 Program: Results of the French-Russian Study on Peaceful Use of plutonium from Dismantled Russian Nuclear Weapons, in IAEA: Nuclear fuel cycle and reactor strategies: Adjusting to new realities, Proceedings of an International Symposium held in Vienna, 3-6 June 1997, p. 93; Joint United States / Russian Plutonium Disposition Study, Prepared by the Joint U.S.-Russian Plutonium Disposition Steering Committee. U.S. Department of Energy, Washington, D.C., September 1996.

94 See GRS/Siemens/Minatom op. cit. (fn. 93).

95 Agreement Between The Government Of The United States Of America And The Government Of The Russian Federation Concerning The Management And Disposition Of Plutonium Designated As No

the protection of sensitive material. It mentions the use of information barriers during inspections, and defines categories of information classification. In order to circumvent the declassification of the plutonium isotopics, the agreement regulates how this plutonium may be diluted by up to 12 percent with so-called "blend stock" plutonium which is of different isotopic composition and from a non-weapon origin. . This procedure ensures that no conclusions can be drawn on the original isotopics, and means that a larger quantity of plutonium can be disposed of. Furthermore, international verification of the disposition process will be more difficult, as the feedstock blurs accurate material accountancy, and the verification process only starts after the blending has taken place.

In future verification scenarios that aim at a comprehensive verification of nuclear disarmament, the output of the verified dismantlement process – the fissile materials – would also undergo monitoring and accounting. Should the isotopics still be masked, this would create a gap or the need for additional complicated procedures. More declassification of information on fissile materials would facilitate processes like this one and make them less costly, more effective and more convincing.[96]

Fourthly, transparency in fissile materials would also facilitate the verification of future nuclear arms control treaties such as the FMCT that has been under consideration at the Conference of Disarmament (CD) for several years,[97] and which seeks to ban the production of fissile materials for nuclear explosives. It is disputed whether such a treaty should also cover material produced prior to its entry into force. Nevertheless, even if it does only cover future production, its verification will have to monitor production facilities. A prerequisite is a certain degree of transparency of these facilities, which may be problematic for several reasons. Some owners might wish to protect information on their past activities. Some facilities are co-located with weapons production and might reveal other sensitive information, not only isotopics but also information that allows one to draw wider conclusions, for example, about production histories or information on plutonium refabrication. Some states might want to continue with the production of HEU for military naval reactors, and therefore want to protect sensitive information on these reactors. The more secrets must be protected the more complicated and less convincing the verification

Longer Required For Defense Purposes And Related Co-operation, 1 September 2000, text available at: http://www.ransac.org/PrinterFriendly.asp?Doc=pudisp-agree.html.

96 It must be noted that it is doubtful whether the agreement on Pu disposition will be implemented, because of its very high costs and because it is unclear whether the international community will contribute enough funds. See Annette Schaper, Deutsche Abrüstungshilfe für russisches Waffenplutonium – Ein Plädoyer (German disarmament aid for Russian weapons plutonium – an appeal), Reinhard Mutz, Bruno Schoch, and Ulrich Ratsch (eds.) Friedensgutachten 2001, Münster 2001; p. 283. It must also be noted that the transparency envisaged in the agreement is disappointing because it falls far behind past promises. Nevertheless it sets a precedent for further disarmament agreements. See Annette Schaper, Monitoring and verifying the storage and disposition of fissile materials and the closure of nuclear facilities, in: Zarimpas (ed.), op. cit. (fn. 12), p. 206. Furthermore, the U.S. has stalled its own disposition efforts.

97 A. Schaper, Principles of the verification for a future Fissile Material Cut-off Treaty (FMCT), PRIF Reports No. 58, Frankfurt 2001, http://www.hsfk.de/publication_detail.php?publicationid=334&language=de; on the situation and the events in the CD see Rebecca Johnson, Fissile Material talks (Fissban), http://www.acronym.org.uk/fissban/index.htm and reports published in the journal Disarmament Diplomacy, online at http://www.acronym.org.uk.

would become. It is not clear whether these problems can be solved by means such as information barriers or managed access during inspections. It is likely that possessor states will negotiate for an exemption of these facilities from verification, which would be a dissatisfying outcome. This secrecy also poses obstacles to attempts to monitor civilian production sites in nuclear complexes when there is strong civil-military integration.[98]

Verification measures on fissile materials originating from weapons could in principle make use of similar methods as verification measures on weapons components e.g. information barriers and attribute measurements, bringing about the same problems and disadvantages in case of too many secrets. Indeed, there have already been attempts to submit nuclear material from disarmament to IAEA safeguards, but for years there have been problems related to secrecy.[99]

These problems could de-motivate states to engage in arms control negotiations, or they could result in a much more modest outcome. Any declassification of information that touches upon fissile materials for nuclear weapons and their production will be beneficial for future verification and nuclear arms control.

Finally, transparency on other materials relevant to nuclear weapons like civilian HEU, reactor grade Pu or Am-241, Np-237 would contribute to reducing proliferation dangers. The reason is that domestic debates in non-nuclear weapon states on the use, international transfer and control of these materials would be more informed, allowing advocates of cautious non-proliferation policies to offer more objective and convincing arguments and persuading decision makers to acknowledge proliferation dangers posed by these materials.[100] In case nuclear weapon states offer a detailed technical reasoning for a warning of proliferation dangers, experts in non-nuclear weapon states are likely to back them

98 Oleg Bukharin, Integration of the Military and Civilian Nuclear Fuel Cycles in Russia, Science & Global Security, Vol. 4, No. 3, 1994, p. 385; Gennady Pshakin, Methods to cope with Material Protection Problems in Russia and CIS: how to draw a line between civilian and military sector, Paper presented at the International Seminar on Fissile Material Security in the CIS, Bonn, 7-8 April 1997.

99 See next section 3.3.4 on the trilateral initiative.

100 Some examples from Germany shall illustrate this: Until the mid-1980s, many German political decision makers believed that reactor-grade plutonium could not be used for nuclear weapons. Since some experts have offered detailed technical arguments demonstrating the contrary, these claims have gradually faded. For the technical arguments and an overview on the discussions see Kankeleit et al, fn. 58. Another recent debate focused on a new research reactor using HEU fuel. In this case, the constructors also claim that the fuel is not weapons usable, see TU-München, FRM-II press announcement, 27 January 1999, http://www.frm2.tu-muenchen.de/presse/de/mitteilungen/99MIT/ 99mit19.html. (Until the printing of this report, they have not yet removed this link.) An expert commission looking into technical details came to a different conclusion, see Bericht der vom Bundesministerium für Bildung und Forschung eingesetzten Expertenkommission zur Prüfung der Umrüstung des Forschungsreaktors München II von HEU auf LEU (Report of the Expert Commission of the Federal Ministry for Education and Research on the assessment of the conversion of the research reactor Munich II from HEU to LEU), 21 June 1999. The reactor has nevertheless been constructed, but the claim on the HEU fuel is not repeated by politicians anymore. Knowledge on the properties of Np-237 and Am-241 played a role in negotiations on safeguards on these materials. They must also be considered in all other future nuclear arms control concerning fissile materials.

up. As long as explanations remain too vague, it might happen that the warning is not believed.

3.3.4 Overview on the current situation

In February 1996, following a two-year study , the U.S. DoE published a comprehensive report detailing information about U.S. plutonium production and use from 1944 through 1994.[101] It is a result of the Openness Initiative, and consistent with the list of information to be declassified.[102] The release of a similar report on U.S. HEU production, acquisition, and use has been delayed significantly because of the complexity of the data being reviewed and for classification reasons[103] (probably related to naval fuel)In Spring 2000, the British Government published a study providing data on Britain's stockpiles of nuclear material for the purpose of making its disarmament plutonium accessible for IAEA inspections.[104] However, similar data relating to British HEU was not published, probably because this is reserved for nuclear submarines. Nevertheless, the U.S. and British publications on plutonium should be praised as important steps in the right direction. Other NWPS lack comparable transparency initiatives.

It is not surprising that in discussions on the scope of future FMCT negotiations, none of the NWPS except Pakistan[105] is willing to consider the inclusion of those fissile materials produced previously to entry into force – something demanded by a large number of NNWS. In discussions on FMCT verification, NWPS government officials advocate the so-called "*focused approach*", e.g. minimalist verification scenarios that cover only reprocessing and enrichment facilities but that renounce material accountancy.[106]

Most information on the quantities and locations of military plutonium and HEU stocks remains unknown. They are estimated to be about 450 tons of military and civil plutonium and over 1,700 tons of HEU.[107] Only a small percentage of this material is under international monitoring, because of the large amounts that fall within the classifica-

101 US Department of Energy, Plutonium: The First 50 Years: United States Plutonium Production, Acquisition, and Utilization from 1944 through 1994, DOE/DP-0137, Feb. 1996, http://www.osti.gov/html/osti/opennet/document/pu50yrs/pu50y.html.

102 RDD-7, see op. cit. (fn. 23).

103 Kevin O'Neill, Paths to Deep Reductions and Nuclear Disarmament – Status Report on Fissile Materials, in: David Albright and Kevin O'Neill (ed.), the Challenges of Fissile Material Control, Washington, DC, 1999, p. 41, downloadable at: www.isis-online.org.

104 United Kingdom's Defence Nuclear Programme, Plutonium And Aldermaston – An Historical Account, 2000, in the internet at http://www.mod.uk.. For a short critique see William Walker, Plutonium And Aldermaston – An Historical Account, Trust & Verify, No. 92, July 2000.

105 Munir Akram, Ambassador of Pakistan, Statement on the 'Fissile Material Treaty', 11 August 1998, http://www.acronym.org.uk/fissban/pak.htm. Pakistan at that time wanted to know the quantities of fissile materials that India has produced. It is unclear whether this position is still maintained today as Pakistan has resumed HEU production.

106 Victor Bragin, John Carlson, and John Hill, Verifying a Fissile Material Production Cut-Off Treaty, Nonproliferation Review 6, No. 1, Fall 1998, http://cns.miis.edu/pubs/npr/vol06/61/bragin61.pdf.

107 Albright et al., see op. cit. (fn. 83).

tion restrictions .[108] Independent scientists have been able to assess an overview on stocks by methods such as literature searches, interviewing officials, or calculating reactor production from power and operating times. Their margins of error vary depending on the category of material and its condition. In some NWPS, these margins of error are rather large.[109]

The problems that most NWS have with offering more nuclear transparency to the rest of the world is illustrated by their own commitments to the Additional Protocol (adopted in May 1997 by the IAEA member states). It enables new arrangements for strengthening the effectiveness and improving the efficiency of the safeguards system.[110] But the transparency the NWS offer on their civilian nuclear activities still falls short of those of the NNWS.

Declarations of intent to place excess nuclear material from dismantled warheads under international verification have been made on several occasions:

1. A statement issued at the G8 summit in Moscow 1996[111] "We pledge our support for efforts to ensure that all sensitive nuclear material (separated plutonium and highly enriched uranium) designated as not intended for use for meeting defence requirements is safely stored, protected and placed under IAEA safeguards as soon as is practicable to do so".

2. In the Guidelines for the Management of Plutonium, which were agreed between the most important plutonium-using states in 1997, it states that "These guidelines apply to the management of all plutonium in all peaceful nuclear activities, and to other plutonium after it has been designated by the Government concerned as no longer required for defence purposes."[112] A major purpose of these guidelines is to create maximum transparency.

3. Transparency of excess fissile material was also promised by the NWS at the NPT Review Conference in May 2000:[113] "We are committed to placing as soon as practicable

108 David Albright and Kevin O'Neill (eds.), the Challenges of Fissile Material Control, Washington, DC, 1999, p. 41, Appendix 4: Efforts to place excess military fissile materials under international controls, downloadable at: www.isis-online.org

109 Albright et al.; Wright et al., see op. cit. (fn. 83).

110 IAEA, Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards, IAEA document INFCIRC/540, Sep. 1997. INF/CIRC/540 was corrected twice in 1998: in INFCIRC/540/Corr. 1 (12 Oct.) and INFCIRC/540 (Corrected) (Dec.), available at URL < http://www.iaea.org/Publications/Documents/Infcircs/1997/infcirc540.pdf >. For a detailed description and analysis see Erwin Häckel, Gotthard Stein (eds.), Tightening the Reins: Towards a Strengthened International Nuclear Safeguards System, Berlin/Heidelberg/New York, Springer-Verlag, 2000.

111 Moscow Nuclear Safety and Security Summit Declaration, April 20, 1996, para 25.

112 INFCIRC/549.

113 Letter dated 1 May 2000 from the representatives of France, China, Russia, the UK and the US addressed to the President of the 2000 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, NPT/Conf.2000/21, http://cnsdl.miis.edu/npt/npt_5/p5statemt.htm.

fissile materials designated by each of us as no longer required for defence purposes under the International Atomic Energy Agency (IAEA) or other relevant international verification."

The international community is pressing for more transparency. The same has been asked by the EU Council at the NPT Review Conference:[114] "...calling on nuclear weapon States, as agreed at the Moscow G7/P8 Summit on Nuclear Safety on 19 and 20 April 1996 to place fissile material designated as no longer required for defence purposes under appropriate international safeguards and physical protection."

The call has also been repeated in several UNGA resolutions, the latest in November 2001.[115]

It must be noted that these declarations – similar in language to those in the sections on international verification in the PMDA[116] – contain the rather vague phrasing "as soon as practicable", which could delay success indefinitely.

One positive step forward is the negotiations between the U.S., Russia, and the IAEA to submit to verification excess nuclear materials arising from disarmament , the so-called "*trilateral initiative*". Its task is to work out procedures under which weapon-origin and other fissile materials released from defence requirements in Russia and the U.S. – in classified or unclassified forms – could be submitted to IAEA verification.[117] In the case of classified forms, it is envisaged that the material would be submitted in sealed containers, and only a few, not very precise attributes would be verified. For example, it would need to be verified whether the amount of plutonium present in a container exceeds a specified minimum mass value. The accompanying declaration would be(?) similarly vague. The verification techniques used here make use of information barriers.[118] The IAEA would not be able to establish that the materials submitted actually came from dismantled nuclear warheads. However, an important benefit would be irreversibility of disarmament because material once subject to safeguards could never again be used for nuclear weapons. It also offers a means to determine quantitatively just how much fissile material has been removed from defence programmes. The trilateral initiative has the potential to be a starting point for future nuclear disarmament agreements, and for incorporating other NWPS.

114 Council Common Position of 13 April 2000 relating to the 2000 Review Conference of the Parties to the Treaty on the Non-proliferation of Nuclear Weapons Official Journal L 097 , 19/04/2000 p. 0001 (Document 400X0297)), Article 2 (2 i).

115 Resolution 56/24N of the UN General Assembly, 29 November 2001, A path to the total elimination of nuclear weapons.

116 See op. cit. (fn. 95).

117 Press Statement on the Trilateral Initiative, IAEA Press Release, PR 97/26, 30 September 1997; Thomas E. Shea, Verification Of Weapon-Origin Fissile Material In The Russian Federation &United States, IAEA Bulletin, Vo. 41, No. 4, 1999, p. 36; Thomas E. Shea, Potential roles for the IAEA in a warhead dismantlement and fissile materials transparency regime, in: Zarimpas (ed.), op. cit. (fn. 12), p. 229.

118 For details see Shea 2003, fn. 117; and R. Whiteson, D.W. MacArthur, Information Barriers in the Trilateral Initiative: Conceptual Description, Report LAUR-98-2137, Los Alamos, 1998.

3.3.5 Approaching a demarcation line

As with information on nuclear weapons deployments, quantities of weapon usable materials should also be published, since this does not pose any proliferation risks. It is hardly imaginable that second-strike capabilities could be affected by such disclosure. The publication should include breakdowns in political and technical categories and locations, as described in section 3.3.1. A few exceptions may arise in cases of information on insecure facilities, the publication of which could potentially facilitate illegal diversion. An overview is summarised in Table 3 in Appendix A.

3.4 Information related to nuclear tests

3.4.1 Types of information

In discussions on the need for nuclear testing and the scope and verification of the CTBT, a variety of information plays a role,[119] some of which may be regarded as proliferation relevant. The need for transparency and the release of certain information –even if it carries a slight risk of being would contribute to a more informed discussion about the CTBT. But finding a boundary between openness and secrecy is very difficult.

Information related to nuclear tests includes technical properties of former and current test sites. It is needed in order to verify whether or not a test has taken place, its location, yield and purpose. The purpose could be associated with developing new nuclear warheads, reliability and safety of existing warheads, refinement of theoretical models, experiments with and the measuring of the effects of nuclear explosions, attraction of skilled scientists into weapons laboratories or simply a demonstration of power. One might also press for information as to the technical background to the test purposes. As an example, the reliability of weapons must be investigated because of the ageing of plutonium. Plutonium ages because it undergoes radioactive decay, and subsequent phase transitions might deteriorate the performance of a warhead.[120] The traditional means of discovering this information has been via a nuclear test. Technical information on the outcome of a test might also prove interesting. Examples of information on the effects of a

119 There are numerous publications on the CTBT. Useful information sources are the Web-Site of the CTBTO Preparatory Commission: www.ctbto.org and of the Coalition to Reduce Nuclear Dangers: http://www.clw.org/pub/clw/coalition/ctbindex.htm. See also Rebecca Johnson, A Comprehensive Test Ban Treaty: Signed but not Sealed – a review of the CTBT Negotiations in the Conference on Disarmament January – September 1996, ACRONYM Report No 10, May 1997, http://www.acronym.org.uk/acrorep/acro10.htm; Matthew McKinzie (ed.): The Comprehensive Test Ban Treaty: Issues and Answers, Cornell University, Peace Studies Program, Occasional Papers, June 1997. See also John M. Shalikashvili, Findings and Recommendations Concerning the Comprehensive Nuclear Test Ban Treaty, January 2001, http://www.state.gov/www/global/arms/ctbtpage/ctbt_ report.html; Committee on Technical Issues Related to Ratification of the Comprehensive Nuclear Test Ban Treaty, National Academy of Sciences, Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty, Washington D.C., 2002, http://www.nap.edu/html/ctbt/

120 Raymond Jeanloz, Science-Based Stockpile Stewardship, Physics Today Online, December 2000, http://www.physicstoday.org/pt/vol-53/iss-12/p44.html

nuclear explosion include that relating to nuclides, electro-magnetic pulse (EMP), blast wave, and radiation.[121] The latter information is useful for verification as well as for the hardening of conventional weapons against nuclear radiation.

Information concerning other experiments or activities that may replace nuclear tests, such as the U.S. "*science based stockpile stewardship*" (SBSS),[122] or similar activities in France[123] would also be useful. One such activity is supercomputing, for example, in the modelling of a nuclear explosion for a certain warhead. NWPS and proliferators develop extensive computer codes for each warhead type. They simulate the various physical processes that take place during the explosion and its various stages.[124]

Another experiment with some potential to lessen the need for nuclear testing is "*inertial confinement fusion*" (ICF). It is the explosion of a small "fusion secondary", which is not ignited by a nuclear fission explosion but by high power lasers.[125] The principle physics are the same as in the ignition and explosion of a secondary in a nuclear weapon.[126]

Other experiments, which involve no self-sustaining nuclear reaction, are described as "*sub-critical tests*" and are therefore consistent with the CTBT (which the U.S. has signed

121 A lot of this has been declassified since a long time. It is mentioned in this report for the sake of completeness. See Samuel Glasstone, P.J. Dolan, The Effects of Nuclear Weapons, Washington 1977.

122 US Department of Energy, Stockpile Stewardship Program: 30-Day Review, 23 Nov. 1999, http://www.fas.org/nuke/guide/usa/doctrine/doe/Conrad.pdf; See also JASON and the MITRE Corporation, Science Based Stockpile Stewardship, Report JRS-94-345, November 1994. A summary is: Richard L. Garwin, Stockpile Stewardship and the Nuclear Weapon Complexes, Pugwash Meeting No. 206, Moscow, 19-23 February 1995; JASON, Nuclear Testing – Summary and Conclusions, JSR-95-320, August 3, 1995, http://www.fas.org/rlg/jsr-95-320.htm

123 René Galy-Dejean, La simulation des essais nucleaires (the simulation of nuclear tests), Rapport D'Information No. 847, Commisssion De La Defense Nationale et des Forces Armées, Assemblée Nationale, 15 Decembre 1993.

124 These are the explosion of the high explosive, the generation of shock waves compressing the primary which consists mainly of the pit, the build-up of a nuclear chain reaction in the compressed fissile material, the generation of fission energy and fission products, the conversion of energy into X-radiation filling a casing that contains both the primary and a "secondary" which consists mainly of fusion materials, the ablation of the outer skin of the secondary and the resulting generation of shock waves compressing it, the formation of a hot spark at its center where the shock waves collide, the starting of significant numbers of fusion reactions in the spark region ("ignition"), the formation of a fusion burn wave in the compressed material travelling outside, the release of fusion energy and heating of the plasma, its expansion, its radiation and the other nuclear weapon effects. Advanced codes are three dimensional and probably take all these and other processes into account.

125 The National Ignition Facility (NIF) And The Issue Of Nonproliferation, Draft Study Prepared by the U.S. Department of Energy, Office of Arms Control and Nonproliferation, (NN-40), August 23, 1995; Committee for the Review of the DOE Inertial Confinement Fusion Program, Commission on Physical Sciences, Mathematics, and Applications, National Research Council, Review of the Department of Energy's Inertial Confinement Fusion Program – The National Ignition Facility, National Academy of Sciences, March 1997, http://www.nas.edu/cpsma/icf.htm#Contents. In principle, there could also be other energy sources than lasers, notably heavy ion beams. But these experiments are still in a less advanced stage of research and development.

126 All processes of the secondary listed in fn. 124 are the same (e.g. starting with "ablation of the outer skin of the secondary...").

though not ratified).[127] The first sub-critical tests conducted by the U.S. have caused a lot of international irritation because they took place underground at the Nevada test side and were perceived by many as real nuclear tests and, therefore, as a violation of the CTBT.[128] International concern has also been raised in the CD.[129] A major reason for the suspicion was the original lack of more technical information that might have confirmed that these experiments had indeed been sub-critical.[130]

Experiments that have also been contested have been so-called *"hydronuclear experiments"*.[131] They are very small nuclear explosions with a nuclear yield below about 4kg of TNT. The international understanding is that hydronuclear tests are banned by the CTBT.[132]

There are several more activities and experiments that have more or less some potential to replace underground testing e.g. calculations of physical properties that are relevant for nuclear weapons, such as opacities and dynamic equations of the state of hot, dense plasmas, other experiments producing hot, dense plasmas, testing of weapons components, investigating material properties or causing some fusion reactions by imploding fusion material with conventional high explosives.[133]

There is a certain overlap of these activities with civilian science. One example being astrophysics, where the theoretical physics is very similar to that of nuclear explosions.

127 S. Drell (Chair), F. Dyson, D. Eardley, R. Garwin, R. Jeanloz, R. LeLevier, W. Panofsky, R. Schwitters, S. Treiman, Subcritical Experiments, Report MITRE/JASON, JSR-97-300, March 1997, http://www.fas.org/rlg/jsr97300.htm.

128 Frank von Hippel and Suzanne Jones, Take a hard look at subcritical tests, The Bulletin of the Atomic Scientists, Vol. 52, No. 6, November/December 1996, http://www.thebulletin.org/issues/1996/nd96/nd96vonhippel.html.

129 See R. Johnson, op. cit. (fn. 119).

130 Annette Schaper, Sub-critical tests and the problem of transparency of a nuclear test ban, Paper presented to the 3rd Pugwash Workshop on "The Future of the Nuclear Weapon Complexes of Russia and the USA", Moscow, 24-26 March 1996. A year later, more information on subcritical tests has been provided by the publication of the MITRE/JASON report, see fn. 127. This renowned panel of trustable independent scientists also has certified that the experiments were indeed sub-critical. Nevertheless, such a certification is not a replacement of international verification as the panel was composed exclusively of U.S. nationals. Meanwhile, other NWPS have also performed sub-critical tests. See the publications of the Acronym Institute for a collection of all press releases on sub-critical experiments: www.acronym.org.uk.

131 See publications of op. cit. (fn. 122); Ray E. Kidder, The Utility of Hydronuclear and Other Tests for Stockpile Evaluation, Maintenance, and the Development of New Weapon Prototypes, Working Paper, March 30, 1995.

132 Annette Schaper, The Comprehensive Test Ban Treaty from a Global Perspective, in: McKinzie (ed.), op. cit. (fn. 119).

133 Suzanne L. Jones and Frank N. von Hippel, The Question of Pure Fusion Explosions Under the CTBT, Science and Global Security, Vol. 7, No. 2, 1998, p. 129-150, C. E. Paine and M.G. McKinzie, Does the U.S. Science-Based Stockpile Stewardship Program Pose a Proliferation Threat?, Science and Global Security, Vol. 7, No. 2, 1998, p. 151-193,, A. Schaper, The Problem of definition: just what is a nuclear weapon test? in: E. Arnett (ed.): Implementing the Comprehensive Test Ban, SIPRI Research Report No. 8, 1994.

Another example is ICF research that takes place in a number of NNWS with the remote purpose of exploring future energy systems.[134] Other experiments might serve conventional military research and development in addition to nuclear weapon research, notably the generation of shaped shock waves. There is no clear demarcation between activities that serve the replacement of nuclear tests and nuclear weapon physics and other purposes or pure science. Similarly, a sensible demarcation between openness and secrecy concerning these ambivalent activities will be blurred, as there are as many arguments in favour of classification as there are against.

3.4.2 Reasons for secrecy

As the types of information depicted above cover a broad range, some of them must be considered separately. First of all, there is information on existing and former nuclear test sites, such as geological properties. This information can be used to calculate yields of nuclear tests from seismic signals.[135] There is no proliferation danger arising from this information. However, a state conducting a test might want the world to believe that it has achieved a different yield to the one actually managed. If so, it might be reluctant to release too much information that allows the outside world to discover this fact.[136] Similar considerations apply to information on weapons effects. Radioisotopes released by a nuclear detonation e.g. by venting from under ground, may also reveal some information about the nature of the explosion, such as whether it has been a thermonuclear warhead or not or whether special materials had been used for the construction of the warhead. The first Soviet thermonuclear explosion, which was above ground, was identified by the U.S. by analysis of nuclides in the atmosphere. In case of an underground explosion, a precise analysis of leaks of radioisotopes might eventually also need on-site inspections. This is part of the verification system envisaged for the CTBT (although the Treaty is not yet in force). During the negotiations, some delegations of NWPS were opposed to verification that was too intrusive, the reasons for which can only be guessed. Probably they generally oppose too much transparency concerning their nuclear weapon related activities, without considering the specific reasons why. Information on radioisotopes and radioactive particles released by nuclear tests and other nuclear weapon effects do not pose any proliferation danger.

Information on the intentions of nuclear tests might reveal potential weaknesses or strengths. Examples of weaknesses are tests in order to improve the reliability or the safety of warheads. An example of strength is the ability to develop a new warhead with special

134 This purpose is frequently quoted in NNWS in funding requests and presentations for a broad public. In fact, prospects for future energy systems based on ICF are very remote. Scientists mostly do science just as an end in itself. Once on a scientific track, a scientist might be led into various directions without much concern about potential practical applications. In the case of ICF, a motivation is created by similar projects and investments elsewhere. See also Schaper 1991, op. cit. (fn. 53).

135 For an overview on CTBT verification methods see the website of the Preparatory Commission for the Comprehensive Test Ban Treaty Organization, www.ctbto.org

136 As an example, the yields of the tests India has conducted in 1998 were estimated far lower by seismic experts than declared by the Indian government.

capabilities. The more detailed information is made available, the more conclusions can be drawn on current military capabilities. During the Cold War, such information was principally guarded. Later, especially in the context of discussions on the desirability of a CTBT, much more has become available, especially from the U.S. and Russia. But "national security" might still be the reason why other NWPS keep secret the purposes of their former tests. The release of information on test purposes does not pose any proliferation danger.

The proliferation dangers of information on test replacement technologies are contested. Paine and McKinzie reason that "dissemination of SBSS nuclear weapons research will tend to erode the Treaty's security benefits".[137] They believe that research such as ICF experiments on hot dense plasmas produced by high power lasers might spread nuclear-weapon-related knowledge to other countries. In their opinion, "more openness of the labs, more publications, presentations at conferences on the SSBS and peer review with the open academic community carry a danger that similar research is motivated in other countries, and that it inevitably will spread more information on thermonuclear weapons".

On a general level, big scientific projects always trigger interest among the scientific community worldwide and often create a lobby in favour of similar research without reference to possible proliferation dangers. Today, any assessment of proliferation dangers of big projects prior to funding is an exception.[138] While research in NNWP is not intentionally aimed at developing thermonuclear weapons, it can inadvertently yield some information that is proliferation relevant, and that might be classified in the NWS. There are examples of this having happened in the past. One example is publications on ICF that explain the principle of "indirect drive" at a time when this was still classified in the U.S. and other NWS.[139] However, these publications are only based on analytical reasoning, without experimental input from any large experimental facility.[140] The proliferation rele-

137 Paine, McKinzie, op. cit. (fn. 133).

138 The IAEA has started an effort to establish criteria to assess proliferation risks of innovative nuclear fuel cycle and reactor concepts prior to their development, in the hope that they might practically be used. However, these criteria do not cover research projects on fusion such as ICF facilities. See Peter J. Gowin and Jürgen Kupitz, Supporting Innovation - International Project On Innovative Nuclear Reactors &Fuel Cycles Moves Into First Phase, IAEA Bulletin, 43/3/2001, http://www.iaea.org/Publications/Magazines/Bulletin/Bull433/article8.pdf; Guidance for the evaluation of innovative nuclear reactors and fuel cycles – Report of Phase 1A of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), IAEA-TECDOC-1362, Vienna, June 2003, see chapter 4.5. Proliferation resistance, p. 106.

139 E.g. heating of a casing by intense laser beams that then fills with black body radiation (X-rays), and the processes described in fn. 124 in the entry of ICF, instead of direct heating. For early publications see J. Meyer-ter-Vehn 1982 and 1987, op. cit. (fn. 54).

140 Meyer-ter-Vehn 1982 explains and interprets the results of extensive ICF computer simulations conducted by the Livermore Laboratory. The Laboratory had published only some results (driver energy versus gain curves), but did not elaborate on details because they were classified, it just called the results "based on conservative assumptions or on less conservative assumptions, respectively". Meyer-ter-Vehn has provided a quantitative model that analytically recalculates the curves and also explains processes in the ignition and explosion of a thermonuclear secondary.

vant information that has come out is that relating to the principle mechanism of the functioning of the ignition of thermonuclear weapons. However – notwithstanding the intellectual achievement of its inventors – this principle mechanism can probably be reinvented again and again and – in any case is public knowledge. In the U.S. it was declassified in the early 1990s. Its usefulness for a proliferator's program for thermonuclear weapons, however, is limited because the major part of the work would still need to be done.

The proliferator needs to know a lot of parameters that can only be measured experimentally, including the exact amount of energy per time released by a fission bomb. These data can only be acquired by nuclear tests of fission primaries. Some of the data can be measured using other experiments, e.g. ICF and plasma physics with high energy lasers. The hotter and denser an experimentally produced plasma is, the more similar it is to a nuclear explosion and the more proliferation relevant are the data that it yields. The proliferation relevance is also dependent on the materials involved. In principle, such experiments can also produce data that could be useful for the development of not only thermonuclear but also ordinary fission bombs, because plutonium or uranium plasmas could also be created. Data on the physical properties of such plasmas can be used as inputs to computer simulations of nuclear explosions. However, provided there is no interest in nuclear weapon research, the likelihood is remote that civilian research in a NNWS will focus just on nuclear weapon materials and yield data that are useful for a nuclear weapon program. Similar considerations also apply to computer simulations and other nuclear test replacement experiments: Quantitative data that are useful for the development of nuclear weapons pose a proliferation danger when declassified. Proliferators who are mainly interested in such data are countries that are already able to master simple nuclear explosions and which are aiming to advance to developing thermonuclear devices. Owning an advanced high-energy ICF facility could be useful for this aim. However, its construction would be a very expensive and complex endeavour. A more simple and direct approach would be to conduct nuclear tests. Probably such countries aim at to send scientists to international collaboration at ICF facilities in other countries. In order to avoid proliferation dangers, experiments in international collaboration, therefore, should not yield sensitive data as described above.

3.4.3 Advantages of transparency and arms control benefits

Transparency of information on geological properties of test sites and on information on nuclear weapon effects has the obvious advantage of enabling CTBT verification. These arms control benefits are hardly contested anymore.

Transparency of the intentions of nuclear tests enables an educated discussion on the desirability of the CTBT and gives a realistic view on the role of nuclear testing in nuclear armament. The arms control goal of the CTBT is to end the qualitative arms race, by ending the development of any new types of nuclear weapon. Other test purposes, for example, to ensure the safety and reliability of existing nuclear warheads will remain as long as the nuclear weapons still exist. The use of test replacement activities should not violate the spirit of the CTBT by serving as a means of developing any new type of nuclear weapon.

Instead, they should only ensure the safety and reliability of existing nuclear warheads. But such activities raise a lot of suspicion within the international community.

Transparency of information on test replacement technologies would help to make claims about the purpose of these tests more plausible, thereby serving to appease concerns that they might undermine the CTBT. Experiments that are conducted behind closed doors raise suspicions: do they also promote the development of new nuclear weapons, or do they only replace legitimate nuclear test purposes? Experiments that are conducted openly, with transparent technical details, enable an independent evaluation, and an educated discussion about whether they have the potential to undermine the CTBT. An example of such openness is enabling international monitoring to determine whether sub-critical experiments are indeed sub-critical. Relevant measurements, including, for example, neutron yields, could be made without compromising classified information on bomb designs.[141] It is possible to create a monitoring regime on a more limited level of transparency, for example, with the CTBTO keeping details of its information confidential but publishing a certificate. Where these experiments are conducted at former test sites it would be necessary to allow access to visitors and international observers. Rather than establish any formal monitoring regime it would be easier to have international staff present at experiments. As a side-effect, internationalisation of staff at large experimental facilities would also help to reduce the chances of any experiments that are too proliferation relevant being conducted. It is the nature of the scientific community to automatically create transparency via communication and publication beyond state boundaries.

Not only CTBT verification would benefit from transparency on information related to nuclear tests, it would also generally enhance international confidence in the compliance with the spirit of this treaty.

3.4.4 Overview on the current situation

Central to the transparency on information related to nuclear tests is the CTBT, and public and international discussions related to this information have taken place in the context of its negotiation and ratification. At present, the treaty is in a dormant stage. The U.S. has failed to ratify it along with a number of other key states and the current U.S. administration shows little intention of doing so. Currently, the five nuclear weapon states are observing a test moratorium. It is unclear for how long this moratorium will be maintained as there are plans for new U.S. nuclear weapons.[142] In this context, there have already been calls for new nuclear tests. India's nuclear tests have probably yielded lots of data that are useful for the development of thermonuclear weapons.

141 See Jasons 1995, op. cit. (fn. 122).

142 Charles D. Ferguson, Mini-Nuclear Weapons and the U.S. Nuclear Posture Review, CNS Research Story of the Week, 8. April 2002, http://www.cns.miis.edu/pubs/week/020408.htm; on a technical assessment see Robert W. Nelson, Low-Yield Earth-Penetrating Nuclear Weapons, Science and Global Security, Vol. 10, 2002, pp. 1–20.

The discussions on test purposes and test replacement technologies have almost exclusively been triggered by the U.S. plans for a Science Based Stockpile Stewardship (SSBS).[143] The SSBS is the scientific and engineering effort to maintain the US nuclear deterrent in the present era of no underground testing. The program has three essential parts: 1) monitoring of the weapons in the enduring stockpile; 2) repair and re-manufacture of components to remedy any degradation observed in surveillance; and 3) basic research to identify what happens in the ageing process and to ensure that any refurbishments are adequate and appropriate. Much of the basic science is completely unclassified. For this reason, basic research programs are conducted with close collaboration between researchers inside the national laboratories and those in academia, both within the US and abroad. A prominent example of international cooperation is laser-based research, such as ICF. The DoE has taken efforts to motivate civilian research centres, notably at universities, to take part in research that might be useful for the SSBS, and has provided substantial funds that these institutions can apply for. An example of such a funding program is the Academic Strategic Alliances Program (ASAP), aimed at promoting collaboration on computing, large-scale modelling, mathematics and computer science.[144]

There are several goals of these transparency efforts. Major aims are to acquire new ideas and to enhance the attractiveness of the weapons laboratories in a non-explosive testing era. Too much secrecy blocks the free flow of creativity that is a natural outcome of exchanges in the open science. According to Siegfried Hecker, former director of the Los Alamos National Laboratory, stockpile stewardship requires more science, not less, and more science requires access to the international scientific community, not isolation.[145] Another motivation is to impress the rest of the world with the U.S.'s technical abilities.[146] Previously, these goals had been served by nuclear tests. One side effect of the transparency efforts are the arms control benefits (3.4.3) and certain proliferation risks (3.4.2).

Similar transparency efforts are not visible in other NWPS, although it has become known that nuclear test replacement experiments are being conducted elsewhere. A prominent example is a large French ICF plant, the Laser Megajoule (LMJ) at Bordeaux, which has a similar design to the U.S. national ignition facility (NIF) at Livermore. Both countries collaborate with each other on this research. There are also ICF plants and sub-critical experiments in other NWPS.[147]

143 See op. cit. (fn. 122).

144 Lawrence Livermore National Laboratory, Academic Strategic Alliance Program (ASAP), http://www.llnl.gov/asci/alliances/. This intensified collaboration and transparency has been criticised by Paine and McKinzie as too proliferation risky, see section 3.4.2.

145 Siegfried S. Hecker, Between Science and Security, Washington Post, March 21, 1999; Page B01

146 Siegfried S. Hecker, Hearing of the Subcommittee on Strategic Forces, Committee on Armed Services, United States Senate, March 19, 1997, quoted from Paine & McKinzie, op. cit. (fn. 133), see endnote 10 of their publication.

147 See the publications of the Acronym Institute for a collection of all press releases on sub-critical experiments: www.acronym.org.uk.

3.4.5 Approaching a demarcation line

The reasoning of the section on test-related information is summarised in Table 4 (Appendix A). As there is no proliferation danger associated with the release of information on properties of tests sites, on effects of a nuclear explosion, on historical data of nuclear tests, on test purposes and on plans of developing new nuclear weapons, all this information should ideally be declassified. Similarly, the purposes of test replacement activities should become publicly known, in order to understand whether they comply with the CTBT. In the case of sub-critical tests, international monitoring should become possible.

The test replacement experiments have the potential to pose some proliferation dangers, as they are inherently ambivalent in respect of their civilian and military character. The boundary between them is blurred, and might be blurred even more by the fact that some NWS are intensifying their civilian research specifically in order to gain benefits with military applications. Transparency is necessary in order to allow an educated discussion on CTBT compliance and to avoid proliferation dangers. Classification is necessary on special numeric data or methods of how to calculate or compute them in case they are useful in nuclear weapons programs.

4. Outlook

The ideal demarcation between transparency and secrecy outlined in this report is still far from reality. A preliminary view shows that the U.S. is by far the most open, in comparison to the other NWPS, and the differences between them seem striking. Much progress in nuclear arms control and disarmament can only be expected when there is progress in nuclear transparency in other NWPS.

The reasons for the differences are still unclear. Why is the U.S. so much more open than the others? Can this be explained solely by democratic traditions exemplified by the FOIA? But if so, why is there a current trend to reverse the achievements of the Openness Initiative? How does the decision-making on classification or declassification work in the other NWPS? Can the differences be described in more detail e. g are there demarcation lines that can be identified and compared to the U.S. classification, as reflected in RDD-7?[148] Is it possible to identify criteria similar to those in the U.S. Openness Initiative?[149] And how can the differences between the other NWPS be explained? Is a democratic constitution an important factor? But then France is a well-established democracy but surprisingly opaque concerning its nuclear-weapon-related information. Russia is in the process of democratisation, but its transparency seems to be on a decline. India is a democratic country too, but its nuclear complex is shrouded in secrecy. Which role is played by traditions and by power structures of the bureaucracies? Do the nuclear weapon development

148 Cf. op. cit. (fn. 23).

149 Cf. DoE document quoted in op. cit. (fn. 18).

complexes have an influence? Which political motives and driving forces of classification and declassification policies can be identified? Who are the major decision makers and players? Can a difference in attitude be observed between nuclear weapon physicists, politicians, and bureaucrats? How is secrecy be influenced by the perception of the own security? What has been the impact of the end of the Cold War? And finally, what are the conditions under which more transparency favourable for arms control could be expected?

A Tables depicting demarcation lines between secrecy and transparency

Table 1: Depiction of a demarcation line for information on nuclear warhead arsenals and deployments

Information	Arms control advantages of declassification	Proliferation concerns	Most important security concerns (deterrence)	U.S. demarcation	ideal demarcation
warhead numbers	Confidence building, indicator of peaceful intentions, provides realistic image of capabilities	None	None	past total numbers up to 1961, current is classified	declassification of all this information
Identification numbers and names				Classified	
warhead types				Classified	
Yields				Total megatonnage of retired warheads is declassified	
Operational statuses, e. g. deployed, reserve, in maintenance, retired etc.				only number of retired or dismantled up to 1994, number disassembled each year is declassified	
delivery systems and ranges				partially declassified	
Locations		fear of acquisition by illegal groups in case of insufficient security	Second strike capabilities might be challenged	classified, although a lot of information partially available	in case of deterrence strategies, some locations must remain secret
production history		None	None	partially declassified	

Table 2: Depiction of a demarcation line for technical information on nuclear warheads

<table>
<tr><th>Examples of information</th><th>Arms control advantages of declassification</th><th>Proliferation concerns</th><th>Most important security concerns (deterrence)</th><th>U.S. demarcation (RDD-7)</th><th>ideal demarcation</th></tr>
<tr><td>isotopic composition</td><td>facilitates technical disarmament measures and verification</td><td>advantages of certain compositions are known anyway, other prol. concerns not imaginable</td><td rowspan="7">A combination of several aspects of this information together with other information might allow an assessment of strengths and weaknesses of the nuclear arsenal, which eventually might be exploited for countermeasures</td><td>classified as long as in warhead component, declassified when modified</td><td rowspan="9">Can largely follow the U.S. demarcation</td></tr>
<tr><td>chemical composition</td><td rowspan="6">facilitates warhead identification during verification</td><td>might be useful in a beginner's program</td><td rowspan="6">classified</td></tr>
<tr><td>mass and shape of specific warheads</td><td>usefulness limited as long no other information is known</td></tr>
<tr><td>size of a pit, and of its reflector</td><td>useful in a beginner's program, but only together with information on the high explosives</td></tr>
<tr><td>the types and shapes of conventional explosives and other components</td><td rowspan="2">very useful in a beginner's nuclear acquisition program</td></tr>
<tr><td>mass, shape and design of secondaries</td></tr>
<tr><td>mass, shape and design of secondaries mass, shape and design of secondaries</td><td>useful in an advanced nuclear program, such as India</td></tr>
<tr><td>basic theories and science related to nuclear weapons</td><td rowspan="3">enables education of negotiation partners in nuclear arms control</td><td rowspan="2">useful in a beginner's program – however, widely known anyway</td><td rowspan="2">None</td><td rowspan="2">Large parts of basic theories have been declassified, except specialised methods that enable the calculation of quantities that are useful in nuclear weapon codes, they include properties of matter, hydrodynamics and radiation transport, other transport phenomena, unspecific design information, including mass and dimension limits</td></tr>
<tr><td>basics of the functioning of nuclear weapons</td></tr>
<tr><td>performance information, e.g. yield-to-weight ratios, or high efficient use of fuel</td><td colspan="2">remote possibility that construction details can be deduced, which would pose a proliferation danger and eventually enable countermeasures – however, unlikely in most cases</td><td>Classified</td><td>should mostly be declassified</td></tr>
</table>

Table 3: Depiction of a demarcation line for information on fissile material stocks and production facilities

<table>
<tr><th>Information</th><th>Arms control advantages of declassification</th><th>Proliferation concerns</th><th>Most important security concerns (deterrence)</th><th>U.S. demarcation</th><th>ideal demarcation</th></tr>
<tr><td>quantities of Pu</td><td rowspan="7">complements transparency on warhead stocks; promotes international confidence in disarmament process; facilitates international nuclear disposition efforts and reduces its costs; raises the international awareness of the need to control these materials would facilitate future verification, e.g. FMCT</td><td colspan="2" rowspan="3">None</td><td>Declassified</td><td rowspan="7">should be declassified, naval fuel should be included</td></tr>
<tr><td>quantities of HEU</td><td>Declassification efforts announced</td></tr>
<tr><td>quantities broken down in political categories, cf. section 3.3.1</td><td>Declassification on Pu, except that the quantities officially declared excess seem to be less than the real numbers, no numbers on HEU</td></tr>
<tr><td>Quantities broken down in technical categories, cf. section 3.3.1</td><td>similar proliferation concerns as with technical information on warheads, only for material in warhead components</td><td rowspan="2">Perhaps indirectly useful for deducing strengths and weaknesses, together with other information</td><td rowspan="4">Pu declassified, HEU not yet</td></tr>
<tr><td>Production capabilities and other elements of the nuclear fuel cycle</td><td>none, except facilities reveal details of nuclear warhead production</td></tr>
<tr><td>Quantities broken down in locations, cf. section 3.3.1</td><td colspan="2">in case of insecure locations concerns of illegal acquisitions or sabotage</td></tr>
<tr><td>production histories</td><td colspan="2">None</td></tr>
<tr><td>information on the security of nuclear installations</td><td>enables international collaboration for improvements</td><td colspan="2">facilitates illegal diversion in case of lacking security</td><td>principle standards known, also declassification on some events of security leaks</td><td>should be declassified, except specific information that would facilitate illegal diversion</td></tr>
<tr><td>weapon usabilities of other materials</td><td>enables international measures and safeguards in order to minimise their proliferation risks</td><td>in case of a material not yet been publicly identified as weapons usable and at the same time with easy production and handling</td><td>none</td><td>declassification on several materials</td><td>should be declassified</td></tr>
</table>

Table 4: Depiction of a demarcation line for information related to nuclear tests

<table>
<tr><th>Information</th><th>Arms control advantages of declassification</th><th>Proliferation concerns</th><th>Most important security concerns (deterrence)</th><th>U.S. demarcation</th><th>ideal demarcation</th></tr>
<tr><td>properties of former and current test sites</td><td rowspan="2">necessary for CTBT verification</td><td rowspan="6">None</td><td rowspan="4">None</td><td rowspan="2">largely declassified</td><td rowspan="6">should be declassified</td></tr>
<tr><td>effects of a nuclear explosion</td></tr>
<tr><td>fact that a test has taken place</td><td rowspan="3">serves historical interests (past tests), or understanding of current armament dynamics (present tests)</td><td rowspan="2">historical data declassified</td></tr>
<tr><td>its location and yield</td></tr>
<tr><td>its purpose</td><td rowspan="2">Plans of developing new nuclear weapons have an impact on the security perceptions of others, which the owner of the information might want to avoid</td><td rowspan="2">classified, some historical exceptions</td></tr>
<tr><td>purpose of future testing, plans of developing new nuclear weapons</td><td>serves understanding of armament dynamics</td></tr>
<tr><td>fact that test replacement activities are taking place and their purposes</td><td rowspan="6">international understanding of CTBT compliance</td><td>None</td><td>None</td><td>Declassified</td><td>should be declassified</td></tr>
<tr><td>details of hydronuclear experiments</td><td rowspan="5">special numeric data or methods of how to calculate or compute them are useful in nuclear weapons programs</td><td rowspan="5">None, as long as no specific information on existing nuclear weapons is revealed that offers deduction of vulnerabilities</td><td>some declassified</td><td rowspan="4">Can largely follow the U.S. demarcation</td></tr>
<tr><td>details of supercomputing</td><td rowspan="4">declassified as far as they don't reveal proliferation relevant data as described in this table</td></tr>
<tr><td>details of inertial confinement fusion</td></tr>
<tr><td>details of testing of weapons components</td></tr>
<tr><td>details of subcritical tests</td><td>declassification of some information on test sites so that international verification becomes possible</td></tr>
</table>

B Abbreviations

ABM	anti-ballistic missile
ACDA	Arms Control and Disarmament Agency
ASAP	Academic Strategic Alliances Program
Am-241	americium-241
CD	Conference of Disarmament
CDI	Center for Defence Information
CTBT	Comprehensive Test Ban Treaty
CTBTO	Comprehensive Test Ban Treaty Organization
CTR	cooperative threat reduction
DoE	U.S. Department of Energy
EMP	electro-magnetic pulse
FAS	Federation of American Scientists
FBIS	Foreign Broadcast Information Service
FMCT	fissile material cut-off treaty
FOIA	U.S. Freedom of Information Act
GAO	U.S. General Accounting Office
HEU	highly enriched uranium
IAEA	International Atomic Energy Agency
ICF	inertial confinement fusion
INF	intermediate nuclear forces
INMM	Institute for Nuclear Materials Management
INT	Fraunhofer Institut für Naturwissenschaftlich-Technische Trendanalysen
LMJ	Laser Megajoule (French ICF plant)
MIPT	Moscow Institute of Physics and Technology
MPC&A	material protection, control and accountancy
MOD	UK Ministry of Defence
MOX	mixed oxide fuel
NIF	national ignition facility (U.S. ICF plant)
Np-237	neptunium-237
NNWS	non-nuclear weapon state (as defined in the NPT)
NPT	Non-Proliferation Treaty
NRDC	Natural Resources Defence Council
NWPS	nuclear weapon possessing state (NWS, India, Pakistan and Israel)
NWS	nuclear weapon state (as defined in the NPT)
PAL	permissive action link
PMDA	Plutonium Management and Disposition Agreement
RDD	Restricted Data Declassification
SBSS	science-based stockpile stewardship
SORT	Strategic Offensive Reductions Treaty
START	Strategic Arms Reduction Treaty
UNGA	United Nations General Assembly