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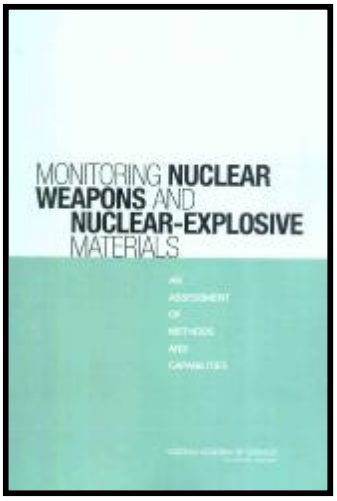

Monitoring Nuclear Weapons and Nuclear-Explosive Materials

An Assessment of Methods and Capabilities (2005)

Just over 60 years ago the United States dropped two nuclear bombs on Japan. Fortunately, no other nuclear weapons have been used in war since that time. The scientific and technical community, working with experts in many other fields, has played an essential role in preventing further use of nuclear weapons. However, one of the greatest challenges facing the world today is how to prevent their use in the future, either by nations or by terrorists.

In 1980, the Committee on International Security and Arms (CISAC) was formed by the National Academy of Sciences (NAS) at a time when the risks to the world from nuclear weapons seemed to be increasing. During a time of extraordinary tensions in U.S.-Soviet relations, CISAC provided a nongovernmental channel of communication between Soviet and American scientists for exploring ways to reduce nuclear dangers. CISAC has now broadened its efforts to include meetings, workshops, and studies to inform Academy members, the wider technical community, and the public at large about key issues at the intersection of science and technology with international security. These efforts have addressed nuclear, chemical, and biological weapons; space weaponry; national missile defense; conventional forces; and the arms trade. A number of CISAC activities have helped shape the debate in the United States and overseas about critical technical issues, as well as larger questions concerning the directions of nuclear weapons policy.

This report by CISAC explores approaches for transparency and monitoring for all categories of nuclear weapons—strategic and nonstrategic, deployed and nondeployed—and nuclear-explosive materials (NEM), and assesses whether and how these technologies could help reduce the dangers from existing nuclear weapons, minimize the spread of nuclear weapons to additional nations, and prevent terrorists from acquiring nuclear weapons.

Positives and Negatives of Transparency

The degree of transparency that countries have permitted concerning their nuclear weapons inventories and NEM has tended to increase over time because it is considered a way to improve security. Transparency can improve opportunities for monitoring, increase confidence in the verification of agreements, and reduce uncertainties in assessing potential threats. On the other hand, transparency may reveal sensitive information that could aid proliferators or increase a nation's vulnerability to attack. Both the United States and Russia have been cautious about sharing information regarding their nuclear arsenals and remain reluctant to provide each other with information related to provide each other with information related to weapon design. Countries with small nuclear arsenals have heightened concerns about sharing information regarding the locations of their nuclear weapons.

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Nuclear Weapons

The necessary tools for enhanced transparency and monitoring for nuclear weapons are either available today or could be available with some additional development. These tools include:

- Cryptography used in banking and other commercial transactions; offers secure way to exchange sensitive information about nuclear weapons.
- Methods to examine from a short distance radiation from a nuclear weapon or to question a weapon container with an external radiation source; permit identification without revealing sensitive weapon design information.
- Tags and seals (e.g. bar codes, tamper-indicating tape, electronic chips); applied to containers and storage rooms for weapons to check their status.
- Monitored perimeter-portal systems that use radiation and other distinctive signatures; confirms what enters and leaves a facility is what it is supposed to be.
- Sensors and accountability systems to monitor declared activity and detect undeclared activity in facilities.

These tools make possible transparency and monitoring measures such as:

- Declarations of nuclear weapon stocks at progressively increased levels of detail ranging from total numbers of weapons; to specification of numbers of different types, including their operational status and associated delivery vehicle; to declarations for each weapon by serial number, weapon type, status, and current location.
- Declarations of name and location of facilities at which nuclear weapons are currently deployed, stored, assembled, maintained, remanufactured, dismantled, or otherwise handled, along with information about each site and its operating history.
- Continuous monitoring of weapon stocks at facilities at all stages throughout the nuclear weapon life cycle, either with personnel on-site or remotely.
- Confirmation of weapon remanufacture and assembly as well as weapon elimination.
- Provisions for routine on-site inspections at facilities to confirm declarations and any updates, as well as for inspections of both declared and suspect sites in the event of detection of suspicious activity or unexplained discrepancies.

Nuclear-Explosive Materials (NEM)

Transparency and monitoring measures for NEM at declared sites include:

- Comprehensive declarations describing quantities and locations of existing NEM, along with information on chemical forms and isotopic composition on the material.
- Declarations of inventories of NEM surplus to military and civilian needs.
- Provisions for inspections of all declared facilities as well as any undeclared suspicious activities.

Transparency for NEM could be supplemented by information from states. The following measures could help reduce stocks of NEM and the number of sites where it is stored:

- Accelerated disposition of excess Highly Enriched Uranium (HEU) inventories through down blending and eventual use in reactor fuel
- Replacement of HEU fuels in research reactors with high-density low enriched uranium fuels and decommissioning of nuclear reactors using HEU fuels when replacement is not possible
- Disposition of excess separated plutonium either by conversion to fuel for use in civil reactors or by immobilizing with fission products in a glass or ceramic matrix
- Comprehensive cutoff of production of NEM for weapons
- Serious international effort to develop nuclear fuel cycles for civil reactors that minimize or eliminate the exposure of NEM
- Centralization under multinational control of all facilities capable of enriching uranium or reprocessing plutonium

Beyond measures to reduce NEM stocks and storage sites, two broader efforts would increase transparency and monitoring. Important efforts to support both of these goals are under way, but they should be enhanced and accelerated.

1) Continued improvements in national management, protection, control, and accounting of NEM holdings so countries are aware of quantity and status of all their holdings and have provided effective protection against theft or diversion for all stocks of NEM.
2) Continued efforts to strengthen safeguards regime administered both bilaterally and by the IAEA, including universal applicability of Additional Protocol, with increased manpower and funding to carry out the expanded mandate.

Clandestine Stocks and Production of Nuclear Weapons

The potential for clandestine activities poses the largest challenge to transparency and monitoring of nuclear weapons. The methods available to detect clandestine efforts to acquire a nuclear weapons include:

- Real-time, high-resolution satellite photography and other satellite sensors. Satellite, ground-based, and sea-based receivers also collect signal intelligence.
- Audits or inspections carried out as part of formal agreements; include use of forensic techniques to reveal illicit alteration of records; may call attention to discrepancies or suspicious activities that suggest potential clandestine activity.
- Human sources, including travelers, emigrants, defectors, "whistle-blowers," and intelligence agents working within the institutions of a state engaged in illegal activities.

CISAC's Conclusions

- Current and foreseeable technological capabilities exist to support verification at declared sites, based on transparency and monitoring, for declared stocks of all categories of nuclear weapons—strategic and nonstrategic, deployed and nondeployed—as well as for the nuclear-explosive components and materials that are their essential ingredients. Many of these capabilities could be applied under existing bilateral and international arrangements without the need for additional agreements beyond those currently in force.
- There are some tensions between sharing information about nuclear weapon and NEM stockpiles and maintaining the security of these stockpiles, but cooperative use of available and foreseeable technologies can substantially alleviate these tensions.
- The nature of NEM production and the characteristics of NEM and nuclear weapons place some fundamental limits on the capabilities of any system of monitoring and transparency to provide assurance of compliance. Accordingly, a degree of uncertainty is inescapable.
- The biggest challenge to the kinds of cooperation-based verification discussed here would arise if countries tried to give the appearance of cooperation while covertly retaining undeclared stockpiles of nuclear weapons or NEM and/or undertaking clandestine production programs. Where concerns about compliance exist, the synergistic effect of multiple technical and management measures, supported by increased transparency and robust national technical means of intelligence collection, could reduce the risk that significant clandestine activities would go undetected and over time could build confidence that verification was effective.
- Important transparency measures for both nuclear weapons and NEM need not necessarily be imposed as part of formal treaties but could be undertaken on the basis of informal understandings or unilateral initiatives, for example, as part of broader confidence-building efforts.
- There are both liabilities and benefits of seeking, in the long run, to incorporate measures governing transparency and monitoring of nuclear weapon and NEM stockpiles into formal agreements. The complexity and intrusiveness of the most ambitious measures mean that negotiation of such agreements may be difficult and protracted. But it is precisely the complexity and intrusiveness of some of the relevant measures that, together with the national security stakes, make formal agreements useful to avoid misunderstandings and to provide mechanisms to clarify ambiguities. In addition, formal agreements provide more durable assurance that measures will be sustained over time and across changes in governmental leadership.

- The synergistic effect of the approaches in a cooperative environment, coupled with robust NTM capabilities, would substantially reduce current uncertainties in U.S. assessments of foreign nuclear weapon and NEM stockpiles over time. Nevertheless, in view of the sheer size and age of the Russian stockpile (where current uncertainties amount to the equivalent of several thousand weapons), Russia probably could conceal undeclared stocks equivalent to several hundred weapons. In the case of other countries with much smaller programs, absolute uncertainties would be much less, leading to the possibility that these countries could conceal undeclared stocks equivalent to one or two dozen weapons in the case of China, and at most one or two weapons in the cases of Israel, India, and Pakistan. Confidence that declarations were accurate and complete, and that covert stockpiles or production facilities did not exist, would be increased by the successful operation of a monitoring program over a period of years in an environment of increased transparency and cooperation.

For More Information

Copies of *Monitoring Nuclear Weapons and Nuclear-Explosive Materials: An Assessment of Methods and Capabilities* are available from the National Academy Press (NAP); (800) 624-6242 or (202) 334-3313, or visit the NAP website at www.nap.edu. For more information on the project, contact staff at (202) 334-2811, or visit the Policy and Global Affairs website at www.nationalacademies.org/pga.