SAND99-0985C

A Uniform Framework of Global Nuclear Materials Management[1]

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Abstract

Global Nuclear Materials Management is a concept that envisions a dynamic, effective, and durable system of national and international programs that address civilian, excess defense, and defense materials. The goal of such management is to ensure the safety, security, and transparency of nuclear materials, worldwide, from cradle to grave. Because effective, uniform, and consistent minimum standards for nuclear materials management are becoming increasingly important in the modern world, we believe it is essential for all states that possess nuclear materials, whatever their policy towards nuclear power and nuclear weapons, to help build and subscribe to such a system. The system, including verification and transparency activities, will likely entail a combination of domestic, bilateral, multilateral, and international regimes.

Introduction

The effective management of nuclear materials, whether these materials are the product of civilian or military nuclear activities, is a fundamental, compelling and enduring responsibility of all states that own or produce such material. The risk to public safety, to nuclear weapons proliferation, and to the environment represented by these materials must be minimized. In addition, it is becoming increasingly important that some assurance of proper management of nuclear materials be provided to the citizens of the State owning the material, and to portions of, or to all of, the international community. The problem of controlling risk to public safety has been a major concern of the nuclear industry since its inception. The problem of preventing the proliferation of nuclear weapons is embodied in the Nuclear Non-Proliferation Treaty (NPT) and the policies, agreements, and treaties that have followed in pursuance of the goals of the NPT. Traditional international safeguards has now been supplemented by the Strengthened Safeguards System to expand the efficiency and effectiveness of the nonproliferation regime. Other international monitoring and cooperative security measures have been discussed and will surely be implemented as they are deemed necessary and desirable to further the goal of nonproliferation. All of this has created a dynamic, challenging, and evolving environment for nuclear materials management.

Global Nuclear Materials Management (GNMM) is a concept developed within Sandia National Laboratories and within the U.S. Department of Energy laboratory complex over the last several years. It was prompted by the agreements between the U.S. and Russia for reductions in their nuclear weapon stockpiles and the resulting declaration of quantities of defense materials as excess to defense needs.

[1] The opinions expressed in this paper are those of the authors and do not necessarily reflect those of the U.S. Government or the U.S. Department of Energy.

DISCLAIMER

The excess defense materials now located in the U.S., Russia, and the UK are a new category of nuclear materials that must be included in the domestic and global processes of materials management.[2] It is the challenge and opportunity presented by these materials that has led to the GNMM concept . However, the concept goes further to include civilian, excess defense, and defense materials in a new, cooperative, and global regime for materials management.

GNMM is based on a vision for the uniform, effective management of nuclear materials worldwide to ensure safe, secure, and transparent use of these materials from cradle to grave. The near-term goal of GNMM is to:

- Continue to build on the excellent past record of success in the safety and security of civilian materials,
- Incorporate excess defense materials into the procedures and processes for materials management, and
- Expand the perspective of organizations owning materials or involved with materials management to include transparency in a uniform and efficient manner.

For purposes of this paper we can define the aspects of GNMM as follows. Safe means that all nuclear materials are under authorized process control and are maintained in an environmentally safe condition at all times. Secure means that all appropriate actions are being taken on a continuing basis to protect the material from loss, theft, or sabotage by credible internal and external threats. Finally, transparent means that all appropriate measures have been applied to provide for assurance and confidence both domestically and internationally that the material is being used as declared and that all safety and security measures are in place.[3]

Figure 1 illustrates the concept of GNMM and offers what we believe is a useful three-lane approach for thinking about the steps necessary for achieving the vision. Traditionally international concern about materials management has been limited to civilian materials. To this we now add defense materials and excess defense materials. At present there is a flow of material between the lanes indicated in the figure, as defense material is declared excess, and as excess material is disposed of by a transition to civilian use or by other means. In the figure a table is shown next to each lane indicating the categorization of materials management activities. These tables show the application of safety, security, and transparency to materials in the U.S., in Russia, and in the rest of the world, respectively.

Although there has been considerable international cooperation on materials management in the past, achieving the vision of GNMM will require additional effort and cooperation among all parties involved in materials management. Under GNMM the global community will be charged with supporting transparency measures to provide confidence to all appropriate parties that at all times the handling of nuclear materials meets global norms for safety, security, and assurance of declared use. This will apply to production, storage, processing, transportation, and disposition of these materials. GNMM will become not just another technique for materials monitoring, but rather a new, cooperative way of doing business.

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[2] One may also consider the high enriched uranium from the dismantled South Africa nuclear weapons, currently under IAEA safeguards, as belonging to this category of material.

[3] In a sense transparency is a means to an end rather than an end in itself; i.e., transparency provides information to outside parties so that these parties can independently assess the safety, security, and declared use of nuclear materials.

As the GNMM vision is achieved, we believe the community involvement in development of mutual standards for safety, security, and transparency of all materials will increase and the resulting standards will become the world norm. Not only will the community integrate strategies for nonproliferation safeguards but it will also develop and implement proliferation-resistant nuclear fuel cycles. Both national and global strategies for disposition of weapons legacy materials will mature, and a regime will evolve to ensure transparency in that disposition. We foresee a time in which all states that possess nuclear materials, whatever their policy towards nuclear power and nuclear weapons, will help build and subscribe to a uniform transparency regime with appropriate inspection and monitoring rights.

Many steps have already been taken to improve and ensure the effective management of nuclear materials. The International Atomic Energy Agency (IAEA) has long served the community as a resource for technical advice and state-of-the-art management practices. However, in many cases the conventions and agreements guiding materials management are voluntary and contain no verification or transparency measures. It is possible that future agreements may make some management measures mandatory,[4] including provisions for inspection or requirements for transparency measures. We believe that a mandatory set of consistent and uniform standards and policies for nuclear materials management, combined with appropriate transparency measures supporting and enhancing community confidence in their application, will enhance the safety and security of these materials. The resulting environment, the product and goal of GNMM, will support the future of nuclear energy, nuclear disarmament, and nuclear nonproliferation.

Security

One area of nuclear materials management that has received considerable attention in the past is physical security. The IAEA has established an International Physical Protection Advisory Service to assist member states in evaluating and improving physical protection systems. On request, the Agency also assists states in the development of legislation and establishment of regulatory systems for physical security, including training of domestic inspectors. Recommended standards for physical protection of nuclear materials are contained in the IAEA publication entitled "The Physical Protection of Nuclear Material" (INFCIRC/225 as revised). These standards were first published in 1972 and have been reviewed and updated several times since.[5] These recommendations have been adopted almost universally and many exporting countries require their adoption by a recipient country as a prerequisite to transferring nuclear materials. In support of these standards, and under the auspices of the IAEA, the U.S. Department of Energy periodically conducts an international training course in physical protection.

In the 1980s, in recognition of the growing problem of international terrorism and the risk posed by the transportation of nuclear materials across national boundaries, the "Convention on the Physical Protection of Nuclear Material" (INFCIRC/274) was developed. This convention, which applies only to

[4] Recent arguments in support of mandatory measures for the physical protection of nuclear materials include: George Bunn, "Physical Protection of Nuclear Materials: Strengthening Global Norms," *IAEA Bulletin* 39, Dec 1977, pp. 4-5. Bonnie D. Jenkins, "Establishing International Standards for Physical Protection of Nuclear Material," *The Nonproliferation Review* 5, Spring-Summer 1998, p. 98. George Bunn, "U.S. Standards for Protecting Weapons-Usable Fissile Material Compared to International Standards," *The Nonproliferation Review*, Fall 1998, pp. 1-7.

[5] See Mohamed ElBaradei, "Physical Protection of Nuclear Materials," *IAEA Bulletin* 39, No. 4, December 1997; and IAEA TECDOC-967, September 1997. See also footnote 9, below.

materials in international transport or in storage incident to such transport, entered into force in 1987.[6] It is another significant step along the path towards the continuing improvement of the security of nuclear materials.

Another agreement, the "Convention for the Suppression of Acts of Nuclear Terrorism," is under consideration. This convention addresses the use of explosive or other lethal devices, including "release, dissemination or impact of toxic chemicals, biological agents or toxins or similar substances or radiation or radioactive material." The convention would extend the scope of international agreements on the physical security of nuclear materials by requiring laws, regulations and technical measures to "ensure the physical protection of nuclear material."

The U.S. and Russia have implemented the "Russian/American Collaboration to Establish a Federal Information System for Nuclear Material Control and Accounting in the Russian Federation." All of the states of the former Soviet Union, with widespread international cooperation, have improved their material protection, control, and accountancy (MPC&A). Procedures for MPC&A are becoming increasingly uniform and standard throughout the world.

Safety

Safety has always been a major concern in the nuclear community. There are numerous documents and agreements in existence covering the safety aspects of civilian nuclear activities. The IAEA is charged with establishing or adopting, in collaboration with other competent international bodies, standards of safety for protection of health and to provide for the application of these standards.[7] Article 2 of the Treaty of Rome, by which the European Atomic Energy Community (EURATOM) was established, calls among other things for that organization to establish uniform nuclear safety standards for the European Community. Many other national and international organizations have contributed to the improvement of civilian nuclear safety.

Attempts to institute an international norm for civilian nuclear safety have recently achieved success. The "Convention on Nuclear Safety" (INFCIRC/449) was adopted in 1994 and entered into force in 1996. The objective of this Convention is to "achieve and maintain a high level of nuclear safety worldwide." It commits states operating land-based nuclear power plants to maintain safety measures based on international benchmarks. Without specifying detailed safety standards, this convention seeks to establish a "commitment to the application of fundamental safety principles for nuclear installations" by requiring the parties to "establish or designate a regulatory body" to govern licensing and operation

[6] The preamble to the convention states that the States Parties to the convention are "aware of the need for international co-operation to establish, in conformity with the national law of each State Party and with this Convention, effective measures for the physical protection of nuclear material." Furthermore the convention stresses "the importance of the physical protection of nuclear material in domestic use, storage and transport." The convention also calls for international assistance in the event of "theft, robbery, or unlawful taking of nuclear material or credible threat thereof." See IAEA INFCIRC/274.

[7] The IAEA has issued an extensive series of documents on nuclear safety. There are also safety standards for IAEA operations and for safety of nuclear power plants within the framework of the IAEA (INFCIRC/18 and INFCIRC/270.) In 1974 the Agency initiated a Nuclear Safety Standards Program for the purpose of establishing internationally agreed nuclear safety standards for land-based thermal-neutron power reactors. In 1991 the Agency began a Radioactive Waste Safety Standards Program. The "Code of Practice on the International Transboundary Movement of Radioactive Waste" (INFCIRC/386) addresses the safe management and disposal of radioactive waste. Numerous agreements exist on incident and accident reporting, response, and liability (see, e.g., INFCIRC/310, 321, 335, 336, 402, and 500, among others.) See also footnote 9, below.

of civil nuclear installations. In another effort along the same lines, the "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management" was adopted in 1997, but has not yet entered into force.

Excess Defense Materials

The need for special treatment of plutonium and high enriched uranium has long been recognized.[8] However, this need was brought to the fore following the end of the Cold War when a new category of nuclear materials was added to the world's inventory – excess defense materials. This category is almost entirely composed of direct-use materials, and much of the material is in sensitive form. The U.S. and Russia have agreed to address issues related to the safety and security of these materials, as well as issues intended to ensure that these materials are not returned to military use.[9] In a Tri-Lateral effort involving the U.S., Russia, and the IAEA the parties have sought methods for establishing transparency to provide confidence to both of the states involved, and to the world, that the former weapons materials are permanently removed from weapons use.

In 1994 the U.S. National Academy of Sciences issued a report recommending the development and implementation of mandatory standards for physical protection of excess defense materials.[10] The terms "Spent Fuel Standard" and "Stored Weapons Standard" were introduced by the NAS studies:

> In order to ensure that the overall process reduces net security risks, an agreed and stringent standard of security and accounting must be maintained throughout the disposition process, approximating as closely as practicable the security and accounting applied to intact nuclear weapons. The Committee calls this the "stored weapons standard." ... The Committee believes that options for the long-term disposition of weapons plutonium should seek to meet a "spent fuel standard" – that is, to make this plutonium roughly as inaccessible for weapons use as the much larger and growing quantity of plutonium that exists in spent fuel from commercial reactors.[11]

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[8] For example, in the Dublin Declaration the European Community made a common policy declaration on enhanced controls to be placed on transfers of plutonium and high enriched uranium. (INFCIRC/322)

[9] At the Moscow Nuclear Safety and Security Summit of April 1996 the participants issued a Declaration that included, *inter alia*, the statements, "The security of all nuclear material is an essential part of the responsible and peaceful use of nuclear energy. In particular, the safe management of fissile material, including material resulting from the dismantling of nuclear weapons, is imperative, not least as a safeguard against any risk of illicit trafficking in nuclear materials. ... Nuclear safety has to prevail over all other considerations. We reaffirm our commitment to the highest internationally recognized safety level for the siting, design, construction, operation and regulation of nuclear power installations. ... Nuclear safety can also be enhanced by greater international transparency in nuclear power activities. ... We recognize the importance of ensuring transparency in the management of highly enriched uranium and plutonium designated as no longer required for defense purposes." (INFCIRC/509)

[10] "Management and Disposition of Excess Nuclear Weapons Plutonium," Committee on International Security and Arms Control, U.S. National Academy of Sciences, National Academy Press, Washington D.C., 1994. See also "Management and Disposition of Excess Weapons Plutonium, Reactor-Related Options," Panel on Reactor-Related Options for the Disposition of Excess Weapons Plutonium, Committee on International Security and Arms Control, National Academy Press, Washington, D.C., 1995.

[11] *Ibid.*, 1994, pp. 147-48.

Although not going into detail about what these standards should be, this report provides insight into the problems and issues related to the security of excess defense materials. The insights provided in the report might serve as a basis for international agreements in this area.

In addition, the NAS study recommends that new agreements be pursued to

1. create consistent, stringent international standards of accounting and security for fissile materials;
2. end all production of fissile materials for nuclear weapons, worldwide;
3. create an international system of declarations and inspections covering declared nuclear weapons arsenals, including reserves, and fissile material stocks (complementing the declarations and inspections already required of non-nuclear-weapon-state parties to the NPT); and
4. create an international safeguarded storage regime under which all civilian fissile materials not in immediate use would be placed in agreed safeguarded storage sites, with agreed levels of physical security.

If these or similar recommendations are ever implemented, any inspection and verification of agreements covering them will add to current national and international inspection regimes. As the NAS study states, "The IAEA secretariat and organizations in several countries are now working on concepts for such universal reporting and safeguarding of civilian fissile materials. The steps, and others that we recommend, would require increased resources for the IAEA, as well as organizational improvements."

Although most efforts to reach agreements on excess defense materials have addressed only those materials, this has not always been the case. Discussions among plutonium-using countries regarding means to limit the stockpiling of civilian plutonium for electric power generation culminated in 1998 with the formal adoption of the "Guidelines for the Management of Plutonium."[12] These guidelines are to apply to the management of both civilian and excess plutonium. Among the provisions in these guidelines is the commitment of the participating governments to manage plutonium in ways that will ensure the peaceful use or the safe and permanent disposal of plutonium subject to the guidelines.

Defense Materials

The subject of nuclear weapon safety and security has recently been addressed jointly by the U.S. and Russia. The "Weapon Safety Agreement Between the United States of America and the Russian Federation Concerning the Safe and Secure Transportation, Storage and Destruction of Weapons and Prevention of Weapons Proliferation" was signed and entered into force on June 17, 1992.[13] This agreement establishes a basis by which the United States will assist the Russian Federation in destroying its nuclear, chemical, and other weapons. It also encompasses efforts to provide safe and secure transportation and storage of such weapons in connection with their destruction, and to establish additional verifiable measures against the proliferation of such weapons. An agreement between the

[12] U. S. Arms Control and Disarmament Agency, Annual Report 1997, Chapter 1, "Controlling Nuclear Weapons." (http://www.acda.gov/reports/annual/chpt1.htm).
[13] *Ibid.*, Appendix A, "Arms Control and Related Treaties and Agreements."

U.S. and Russia concerning nuclear warhead safety and security was signed December 16, 1994.[14] Under this agreement the U.S. Department of Energy and the Russian Ministry for Atomic Energy, as Executive Agents, are to exchange technical information on enhancing the safety and security of weapons and defense materials. Additional agreements related to weapons safety and security appear to be likely in the future.

Transparency

While the conventions and agreements mentioned above in many cases do not incorporate inspections or other forms of verification, there is an increasing need for each State to provide confidence, to their own populace as well as to other States, regarding their effective management of nuclear materials. Transparency is one practical way to do this. Transparency is not verification, at least not in the classical sense. Rather, transparency introduces a new variable into verification measures and procedures. If used properly, it can both simplify and supplement verification while increasing both the efficiency and effectiveness of an inspection regime. Ultimately it may replace many traditional inspection processes.

Confidence building could involve bilateral, multilateral, or international agreements and inspection organizations. In the words of Pablo Benavides, Director General of the European Commission, Euratom provides a prime example of successful confidence building and transparency. "Stable legal commitments and transparency of peaceful nuclear activities are pivotal conditions for developing confidence among Member States as well as with the many third countries which have trading relations with the European Union in the nuclear area."[15]

The U.S. and Russia have a number of agreements in place that include the use of transparency measures, either explicitly or implicitly, as part of the verification or confirmation that such agreements are being implemented as agreed. For example, on February 18, 1993, the U.S. and Russia signed the "Agreement Between the United States of America and the Russian Federation Concerning the Disposition of Highly Enriched Uranium Resulting from the Dismantlement of Nuclear Weapons in Russia." Under this agreement the parties will convert as soon as practicable 500 MT of highly enriched uranium from dismantled Russian nuclear weapons into low enriched uranium for fuel in commercial nuclear reactors. The parties have agreed to establish appropriate measures to fulfill non-proliferation, physical security, material accounting and control, and environmental requirements with respect to the material subject to the agreement, and are seeking effective transparency measures to ensure confidence in the process.[16]

At the January 1994 U.S.-Russian Summit, Presidents Clinton and Yeltsin agreed to seek increased transparency in their countries' respective nuclear weapon stockpile reduction activities. They also agreed to exchange information on stocks of fissile materials. The U.S. has initiated IAEA safeguards on its excess defense materials, and at the January 1994 Summit Russia agreed to consider putting its excess material under IAEA safeguards.

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[14] "Agreement Between the Government of the United States of America and the Government of the Russian Federation on the Exchange of Technical Information in the Field of Nuclear Warhead Safety and Security," signed in Moscow, December 16, 1994.

[15] Pablo Benavides, "Safeguards and Non-Proliferation in the EU: Reflections on 40 Years of Euratom Safeguards and Some Thoughts Concerning Future Developments," Europa, 1998.

[16] U. S. Arms Control and Disarmament Agency, Chapter 1, "Controlling Nuclear Weapons," *op. cit.*

In June 1994 Vice President Gore and Prime Minister Chernomyrdin signed an agreement on the "Shutdown of Plutonium Production Reactors and the Cessation of Use of Newly Produced Plutonium for Nuclear Weapons." The original version of this Agreement never entered into force, primarily because Russia could not be assured that replacement sources of the heat and electricity provided by these reactors could be found in time to compensate for their shutdown. However, Russia stated that as of October 1, 1994, it stopped using newly produced plutonium in nuclear weapons and was instead storing it in the form of plutonium oxide.

On September 23, 1997, Vice President Gore and Prime Minister Chernomyrdin signed a second U.S.-Russian Plutonium Production Reactor Agreement. To ensure compliance with this commitment, the United States is given the right to monitor an estimated 4.5 to 9 tonnes of weapon-grade plutonium produced by these reactors since the beginning of 1995. According to the U.S. Arms Control and Disarmament Agency,

> U.S. monitors will be able to ensure that operating facilities use fuel and production schedules that prohibit production of weapon-grade material, and that recently produced plutonium remains out of nuclear warheads. A Joint Implementation and Compliance Commission has been established to oversee implementation of the agreement's provisions and resolve any issues that may arise. The agreement marks a new stage of U.S.-Russian cooperation to regulate and safeguard nuclear materials, to limit their use in weapons, and to build mutual confidence through increased transparency.[17]

Finally, on March 21, 1997, in Helsinki, Finland, the Presidents agreed that once START II enters into force, the United States and Russia will immediately begin negotiations on a START III agreement. This agreement will include, among other things, measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads.[18]

Verification

As the number and scope of international agreements related to the safety, security, and nonproliferation of nuclear materials continue to increase, the accompanying verification and inspection demands will also likely increase. Transparency, if developed in parallel with these agreements, can greatly assist in minimizing the additional burdens placed on independent, third-party inspectorates. However, even with the implementation of transparency measures, it is probable that such third-party inspectorates will be asked to do more in the future than they have done in the past, at least in the near term. Many of the measures that are voluntary guidelines today may become mandatory standards in the future, and an appropriate international framework will have to be devised and implemented to provide States with assurance that their legitimate concerns regarding the functioning of these standards are being addressed.

It is apparent that the number of agreements that support the transparency and irreversibility of nuclear weapons reductions is rapidly increasing. In many cases, verification of these agreements and implementation of transparency measures have yet to be finalized. Under Article I of the NPT, nuclear weapon states party to the treaty are obligated not to transfer "to any recipient whatsoever nuclear

[17] *Ibid.*
[18] *Ibid.*

weapons or other nuclear explosive devices ... directly, or indirectly." Therefore verification or transparency measures involving weapons components or excess materials in sensitive form must deny to the inspectors any information that would assist in such indirect transfer. This restricts the range of inspection or verification technology that can be used in the inspection of these materials. Under the Tri-lateral Initiative the U.S., Russia, and the IAEA have explored ways to inspect and verify excess materials. Some strides have been made and, although difficult, this is not an impossible task and inspection of excess materials by international bodies appears to be feasible.

The U.S. and Russia have begun to make strides towards the issues of safety and security of weapons and weapons materials. Inspection of weapons by international organizations may be impossible. However, it may be possible to provide for self-inspection, perhaps with some cooperative international certification of inspectors or other confidence building measures. Some bilateral or multilateral inspections involving teams from other nuclear weapon states may also be possible.

Conclusion

GNMM anticipates and supports a growing international recognition of the importance of uniform, effective management of civilian, excess defense, and nuclear weapons materials. We expect there to be a continuing increase in both the number of international agreements and conventions on safety, security, and transparency of nuclear materials, and the number of U.S.-Russian agreements for the safety, protection, and transparency of weapons and excess defense materials. This inventory of agreements and conventions may soon expand into broad, mandatory, international programs that will include provisions for inspection, verification, and transparency. To meet such demand the community must build on the resources we have, including State agencies, the IAEA, and regional organizations. By these measures we will meet the future expectations for monitoring and inspection of materials, maintenance of safety and security, and implementation of transparency measures.

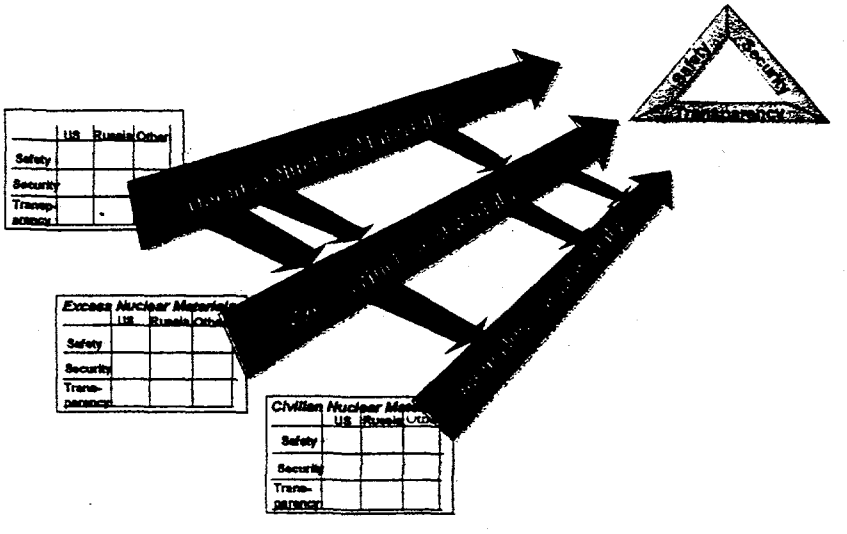

Figure 1. Three-Lane Approach to Global Nuclear Materials Management

Acknowledgment

This work was supported by the U. S. Department of Energy. Over a period of several years many people contributed to the ideas expressed in this paper. The authors especially wish to thank Gary Polanski, Grace Bujewski, Greg Mann, and Pat Falcone for their input and contributions to the GNMM concept. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.