Nuclear Security Governance Experts Group Workshop on Improving Nuclear Security Regime Cohesion
Asan Institute
Seoul, July 18-19 2012

Learning from Nuclear Safety

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Abstract
This paper identifies aspects of the nuclear safety regime that might be adapted to help improve nuclear security governance. It begins with a discussion of what has been learned from major nuclear safety accidents and then identifies particular concepts, principles and requirements that have relevance for nuclear security.

Lessons from Nuclear Accidents

To date, no nuclear security incident has matched the magnitude of the nuclear safety incidents at Three Mile Island, Chernobyl, and Fukushima. By holding two nuclear security summits in the past two years, with a third scheduled for 2014 in the Netherlands, more than fifty heads-of-state have acknowledged the need to act now to avoid potential crises.

In the wake of nuclear accidents, governments and industry have created new organizations, new international legal instruments and new approaches to nuclear safety. Several of these are worthwhile to examine for their relevance to nuclear security.

Without a doubt, the first and immediate impact of a significant nuclear accident is on national safety implementation. More rigorous safety procedures may stem from better implementation of existing standards, new and improved standards, or changes to regulatory structure or oversight. These can come from government or industry or a combination of both. The 1979 accident at Three Mile Island led to significant improvements in the U.S. nuclear regulatory system as well as within nuclear industry. As the NRC describes it,

> There is no doubt that the accident at Three Mile Island permanently changed both the nuclear industry and the NRC… NRC's regulations and oversight became broader and more robust, and management of the plants was scrutinized more carefully. The problems identified from careful analysis of the events during those days have led to permanent and sweeping changes in how NRC regulates its licensees – which, in turn, has reduced the risk to public health and safety.[1]

[1] Nuclear Regulatory Commission, *Backgrounder on Three Mile Island Accident,* available at http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html

Among the major changes identified by the NRC were expansion of the resident inspector program and performance-oriented inspections, upgrades to plant design and equipment requirements, upgrades to operator training and staffing requirements, enhancement of emergency preparedness, including drills and response plan testing, and expansion of NRC's international activities to share nuclear safety information with other countries. Industry collectively established the Institute for Nuclear Power Operations (INPO) as well as a voluntary system of peer reviews for nuclear safety. Such voluntary peer reviews reportedly are taken very seriously by reactor operators, particularly since they are linked in the United States to nuclear power plant insurance.

Larger scale accidents can have even further-reaching impact. Chernobyl galvanized world attention and led to a global effort to improve nuclear safety. The notification and assistance conventions were swiftly adopted, followed by the Convention on Nuclear Safety some years later. International peer reviews were implemented and an international coordinated emergency response system was put in place.

The impact of the 2011 Fukushima accident is still playing out. In Japan, the entire political system has grappled with efforts to improve the independence of nuclear safety regulation. Formerly under the Ministry of Economy, Trade and Industry, the Nuclear Industry and Safety Agency has been reporting to the Ministry of the Environment. It appears now that a Nuclear Regulatory Commission will be established that is linked to the Ministry of the Environment (it will receive its budget from MoE) but does not report through the MoE.

Other countries have reexamined their own nuclear regulatory structures, including South Korea and China. Virtually all countries with nuclear power plants conducted safety evaluations, or "stress tests" and a few shut down power reactors in response. Some additionally slowed their construction plans as they awaited the outcome of safety evaluations. Nonetheless, without an international nuclear safety "inspectorate," it is likely that the quality of those evaluations is rather uneven.

In addition to these national responses, there have been recommendations to improve international responses and standards. Although unlikely to include new conventions or mandatory safety inspections, responses to Fukushima have included recommendations to create an international emergency response team and to strengthen existing approaches. Following the June 2011 ministerial IAEA conference, the IAEA Director General Amano made five recommendations:

- strengthen IAEA Safety Standards;
- systematically review the safety of all nuclear power plants, including by expanding the IAEA's program of expert peer reviews;
- enhance the effectiveness of national nuclear regulatory bodies and ensure their independence;
- strengthen the global emergency preparedness and response system; and
- expand the Agency's role in receiving and disseminating information.

For industry's part, WANO recommended in 2011 "expanding the scope of WANO activities; developing a worldwide integrated event response strategy, improving WANO's credibility including changes to WANO's peer reviews and corporate peer reviews; improving visibility; and improving the quality and consistency of WANO's products and services worldwide."[2]

Nuclear Safety: Applicable Lessons for Nuclear Security[3]

Some steps taken to improve nuclear safety may have the collateral benefit of improving security, for example, ensuring redundant and off-grid power supply in the event of flooding. After Fukushima, many countries have focused on strengthening the independence of national nuclear regulatory authorities. Operators primarily look to their national regulators for safety and security guidance and requirements. Strong, independent, and technically competent regulators are necessary to ensure that rules are instituted and enforced.

Harmonizing accident/incident reporting parameters and expanding information sharing and transparency in a crisis are two other important requirements. The first duty of operators is to manage the crisis, rather than provide information to the public. But, public concerns are important and heavily influenced by the quality of information provided and the transparency of authorities. During the Fukushima accident, governments and media reported complex data that was difficult to translate properly to the lay public and often was inconsistent. Effective analysis and response to nuclear crisis can benefit from clear communications that utilize standardized evaluation metrics and reporting requirements. There is little international consensus on incident reporting beyond the IAEA's international nuclear and radiological event scale, which conveys only the most basic details.

Incorporating security as a fundamental element in new reactor designs would also be helpful. The nuclear industry is committed to continual improvement in safety, as reflected in its efforts to retrofit old reactors with new safety features and incorporate passive safety features into new reactors. Fortunately, many of the new safety designs also contribute to improved security. But safety and security objectives can also be in conflict. It is important that security not be treated as a subset of safety, but rather promoted as a fundamental priority alongside it. Regulators have an important role to play in ensuring that both safety and security culture are robust.

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[2] See http://www.wano.info/about-us/history/

[3] These recommendations are drawn from Ken Luongo, Sharon Squassoni and Joel Wit ,"Integrating Nuclear Safety and Nuclear Security: Policy Recommendations," a CSIS Policy Perspectives Paper, December 13, 2011, available at http://csis.org/files/publication/111214_Integrating_Nuclear_Safety_and_Security_Memo_2.pdf

Several elements of the nuclear safety regime that developed as a result of crises have direct applicability to the nuclear security regime. These include:

- regularized assessments of performance
- information sharing
- peer review
- reviews of the implementation of relevant international conventions and
- strong trade organizations.

Four of these elements are embodied in the Convention on Nuclear Safety (CNS) and have been critical to the improvement of nuclear safety over time. The fifth – strong trade organizations – takes the shape of the World Institute for Nuclear Security (WINS), which was launched in 2008 to provide a forum for sharing and promoting nuclear security best practices. WINS has focused attention on integrating security into nuclear facility operations on a par with nuclear safety. But, it is not as institutionally robust yet as INPO and WANO. Neither of the nuclear security regime's key international conventions –the Convention on the Physical Protection of Nuclear Materials (CPPNM) and its amendment nor the International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT) includes provisions for assessment, information sharing or peer review. A single CPPNM review conference was held in October 1992, five years after it entered into force as required by Article 16, during which unanimous support for the CPPNM was expressed by the 35 states in attendance. CPPNM parties came together again in the late 1990s and early 2000s to strengthen and expand the scope of the convention by amending it to better address threats of nuclear terrorism, smuggling, and sabotage. An amendment was adopted in 2005, but will not come into effect until two-thirds of the state parties ratify the changes. The ICSANT has a provision for an amendment conference but not a review conference.

Safety Concepts and Principles

Fundamentally, nuclear safety and nuclear security serve the same objective: to protect the public and the environment from unintended releases of radiation.[4] Whether for nuclear safety or security reasons, protection starts with good design

[4] Nuclear safety is "the achievement of proper operating conditions, prevention of accidents and mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards." Nuclear security is defined by the IAEA as "the prevention and detection of and response to theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities. Both definitions are available at: http://www-ns.iaea.org/standards/concepts-terms.asp?s=11&l=90#3. These are taken from the IAEA safety glossary and the security glossary. The working definition of nuclear security was agreed upon at the fifth meeting of the Director General's Advisory Group on Nuclear Security (AdSec), 1–5 December 2003.

(of equipment, facilities and sites), follows through with good operational practices, including in transportation, and ends with good design and operation of waste disposal sites. This is necessary not just for nuclear material and facilities but also for radiological materials, which are used at medical, agricultural and industrial sites.

The IAEA addresses the safety-security interface in its *Fundamental Safety Principles*:

> The safety principles concern the security of facilities and activities to the extent that they apply to measures that contribute to both safety and security, such as:
> —Appropriate provisions in the design and construction of nuclear installations and other facilities;
> —Controls on access to nuclear installations and other facilities to prevent the loss of, and the unauthorized removal, possession, transfer and use of, radioactive material;
> —Arrangements for mitigating the consequences of accidents and failures, which also facilitate measures for dealing with breaches in security that give rise to radiation risks;
> —Measures for the security of the management of radioactive sources and radioactive material. [5]

More broadly, nuclear security is a "cross-cutting activity" that benefits from synergies and collaboration with activities taken for safety and safeguards purposes.[6] For example, joint safety and security missions help evaluate national laws and regulations for the control of radiological sources, engineering safety design reduces the vulnerability of vital areas in nuclear facilities to sabotage, and systems for accounting and control of nuclear material deter and/or allow early discovery of theft.

In 2010, the IAEA's International Nuclear Safety Group (INSAG) published "The Interface Between Safety and Security at Nuclear Power Plants."[7] With a backdrop of increased interest in nuclear power, the report aimed to "highlight the importance of a coordinated approach to nuclear safety and security" and the need to "approach safety and security in a fashion that they complement each other." It compared the responsibilities of the state, regulatory authorities and operators for safety and for security, discussed common basic principles between safety and security and how safety and security should be addressed over the lifetime of nuclear power plants. INSAG recommended greater coordination at

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[5] International Atomic Energy Agency, *Fundamental Safety Principles*, (Vienna: 2006), available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1273_web.pdf

[6] See, for example, the 2006 IAEA document, *Nuclear Security - Measures to Protect Against Nuclear Terrorism Report by the Director General,* GOV/2006/46-GC(50)/13

[7] IAEA, *The Interface Between Safety & Security at Nuclear Power Plants,* INSAG-24, available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1472_web.pdf

all levels, while noting the specific need to take into account differences where they exist.

There are certainly similarities in the approaches to protection under safety and under security: both rely on in-depth defenses, both place priority on prevention, early detection, and prompt action, and both require extensive emergency planning.

In a few places, however, nuclear safety and security diverge. Risk assessment is one such area. For nuclear safety experts, an unintended release is the result of an unintentional incident, such as a natural occurrence (like the earthquake and tsunami in Japan), hardware failures, internal events or disruptions, or human error. Nuclear security experts, on the other hand, are most concerned with releases of radiation that result from intentionally destructive acts, including those designed to circumvent protective measures.

A key question is the difference in the use of probabilistic versus deterministic risk assessment. For example, before Fukushima, probabilistic risk assessments for safety did not consider more than one "beyond design basis' event occurring (such as an earthquake and tsunami). On the other hand, nuclear security assessments must contend with the attacker's intention to defeat the system, potentially including a multi-pronged approach.

Another key difference is the approach to information sharing and transparency. In nuclear safety, information sharing is critical to safe operation of plants, and the general inclination is to share information to avoid mistakes being repeated, including at other plants. For nuclear security, information is generally shared among a restricted group in order to maximize information security. Moreover, there may be kinds of information, for example, intelligence reports, which may be crucial to preventing sabotage that lies outside the operators' control. In fact, the role of the state in defining rules for confidentiality is much greater in the case of nuclear security than it is in nuclear safety.

In practice, nuclear security often is implemented by law enforcement personnel, while nuclear safety is the purview primarily of engineers and radiation health experts. These people approach problems in different ways and may work in different organizational structures with different incentives. Safety and security can also sometimes have contradictory imperatives. For example, a security incident could require a lock-down of the facility, whereas an accident would require easy access for operators and emergency personnel. Ensuring that measures are complementary rather than contradictory is important in the design, regulation, and operation of the facility.

Principles, Requirements & Practice

The Convention on Nuclear Safety (CNS), which was brought into force in 1996, outlines fundamental safety principles, rather than specific safety requirements.[8] Rather than enforcing requirements, it encourages compliance through periodic peer reviews. States submit national reports to peer review but requirements for national reports are not detailed. In general, states must adopt national laws to implement their obligations under the CNS to "achieve and maintain a high level of nuclear safety worldwide; establish and maintain effective defenses…against potential radiological hazards; protect individuals society and the environment from harmful effects of ionizing radiation; and prevent . . . and mitigate radiological consequences of accidents." Articles of the Convention cover establishing national safety requirements, licensing and regulatory authorities and procedures, etc.

As in nuclear safety, nuclear security is still very much the purview of the state. Two major international agreements have been reached thus far: the Convention on the Physical Protection of Nuclear Material (CPPNM) and the International Convention on the Suppression of Acts of Nuclear Terrorism (ICSANT). Other agreements include the Code of Conduct on the Safety and Security of Radioactive Sources, and the supplementary Guidance on the Import and Export of Radioactive Sources. The CPPNM, brought into force in 1987, was designed primarily to cover nuclear material in transit. The amendment to the CPPNM, introduced in 2005, seeks a much broader scope for the convention: "to achieve and maintain worldwide effective physical protection of nuclear material used for peaceful purposes and of nuclear facilities used for peaceful purposes; to prevent and combat offences relating to such material and facilities worldwide; as well as to facilitate co-operation among States Parties to those ends (Article IA)." The amended convention, however, will not enter into force until two-thirds of the parties (96 states) have ratified the amendment. As of April 2012, only 56 countries had ratified.

The International Convention on the Suppression of Acts of Nuclear Terrorism, or ICSANT, was adopted by the UN General Assembly on April 13, 2005 (A/Res/59/290) and entered into force in 2007. ICSANT requires states to criminalize the unlawful possession, manufacture or use of radiological and nuclear material or devices or damage to nuclear facilities to release radioactive material by persons. At this writing, 115 states have signed, with 77 of them having ratified the convention.

Supplementing the principles outlined in conventions are guidance documents issued by the IAEA. These include fundamental safety principles and objectives,

[8] See Gunther Handl, "The IAEA Nuclear Safety Conventions: An Example of Successful 'Treaty Management'?" in *Nuclear Law Bulletin*, No. 72, 2001, available at http://www.oecd-nea.org/law/nlb/nlb-72/007_027.pdf

general safety requirements and guides, and general and specific safety guides for particular types of facilities and activities.[9] The safety standards help guide national requirements and serve as the basis for peer reviews. Guidance documents for nuclear security are less comprehensive but include *Nuclear Security Fundamentals* (including Physical Protection Fundamentals and Objectives which was adopted in September 2001 and forms the basis for the amendment to the CPPNM); *Recommendations*, presenting best practices that should be adopted by Member States in the application of the Nuclear Security Fundamentals; *Implementing Guides*; and *Technical Guidance*, comprising reference manuals, training guides and service guides. Note the absence of "standards" in nuclear security documents. Only a handful of the planned 19 documents in the series have been completed. One of the most important documents is the fifth revision of INFCIRC 225, which is categorized as a recommendations document.

Finally, the IAEA provides a range of assistance in nuclear safety and nuclear security. Many of these are specific to one area, but some are more integrated, for example the Integrated Regulatory Review Service (IRRS), which covers all national regulatory authorities, and services related to the safety and security of radiological sources. In nuclear safety, there are about 25 advisory services, across the board. In nuclear security, there are just a handful of assistance missions: International Physical Protection Advisory Service (IPPAS) International Nuclear Security Advisory Service (INSServ), IAEA State System of Accounting & Control Advisory Service (ISSAS), International Team of Experts (ITE) advisory missions and Integrated Nuclear Security Support Plan (INSSP).

Since about 2003, security has been paired bureaucratically with safety at the IAEA. In 2005, the IAEA established an Incident and Emergency Response Center to integrate its preparedness and responses to all kinds of nuclear and radiological emergencies, regardless of their cause. However, it is not entirely clear how much integration has been accomplished on the ground level or how much is desired by states, or by the IAEA itself.

Moving Beyond the Current Paradigm

The nuclear safety and security regimes rely principally on national decision-making, laws, and regulations, supplemented by international agreements and organizations that largely offer voluntary guidance. In general, the implementation of the regimes relies on incentives and many believe that this is preferable to mandatory requirements. However, the voluntary and national nature of nuclear safety and security implementation belies the fact that nuclear crises do not respect borders.

[9] For a useful status of all the IAEA safety documents, see "Long-Term Structure of IAEA Safety Standards and Current Status," January 2012, available at http://www-ns.iaea.org/committees/files/CSS/205/status.pdf

Introducing more binding international standards could address concerns about weak links in national nuclear safety and security regulation and implementation. They could supplement the current regimes without dismantling the incentives in place. The objective would be greater uniformity of safety and security standards and encouraging countries and operators that are lagging to improve so that they meet the highest standards. One option for international standards could include negotiating a baseline for nuclear security, or states could provide advance consent to the IAEA for periodic evaluations of their nuclear safety and security measures, similar to safeguards inspections. Another would be to increase the number of requests and funding for IAEA International Physical Protection Advisory Service (IPPAS) assessments or establishing bilateral or regional exchanges of information.

Barriers to Adopting Elements of the Nuclear Safety Regime

Although adopting (and adapting) certain elements of the nuclear safety regime could significantly strengthen the nuclear security regime, at least four challenges are likely to surface: national sovereignty, information transparency, lack of policy consensus, and challenges of regime harmonization. International conventions, IAEA guidance, and the 2010 and 2012 nuclear security summit documents emphasize the national responsibility for nuclear material security. In the nuclear safety area, accidents like Chernobyl and Fukushima have demonstrated however, that nuclear crises do not respect borders and that there is a need to think beyond national approaches and regulations for sufficient protection of the global community.

The focus on sovereignty with respect to nuclear security is especially highlighted in the area of information security. As noted by the INSAG, "the general rule in the nuclear safety area…is to pursue transparency…[while] in the security field, the sharing of information should typically be restricted to…prevent sensitive information…from falling into the hands of adversaries." Not surprisingly, information exchanges and peer reviews have not played a large role in the nuclear security regime. Nonetheless, some countries, most notably the United States and Russia, have found ways to work together on improving the security of the most sensitive nuclear materials and facilities without compromising security information. Increasing transparency does not mean making sensitive information public. Confidentiality among parties can be maintained, as is the case when countries collaborate with the IAEA on nuclear safety. But information sharing can also promote international confidence. For example, country reports submitted as part of the Convention on Nuclear Safety review process were originally kept confidential, but for the last few years, most have been posted online because countries determined that their interests were better served by openness than secrecy. Also, general knowledge about U.S.-Russia cooperation has increased international confidence in the security of nuclear materials in Russia.

It will ultimately fall to national leaders to decide the policy evolution of the nuclear security regime. Although consensus on policy improvements may be preferable, that process could be difficult and result in inadequate policy solutions. As a complement to this process, countries could begin to evaluate and harmonize the existing elements of the nuclear security regime, especially in the nuclear material security area.

Goal of Continual Improvement

Continual improvement of nuclear safety and security must remain a goal for all countries. It is unclear how international dialogue on nuclear security will proceed after the 2014 NSS. Encouraging civilian nuclear operators to engage with their foreign counterparts on nuclear security best practices is one positive step. Such dialogues would require that sensitive data be protected; however, the U.S. government's engagements with countries like Russia, Pakistan, and China on nuclear security demonstrate that space exists to share best practices without compromising security. The World Institute for Nuclear Security can play a useful role in encouraging such dialogues. Its recent efforts in establishing accreditation in nuclear security training will certainly help contribute to continual improvement. In addition to operators, regulators from different countries also should be encouraged to meet and exchange views and information.

Another step would be to regularize dialogue and interaction among all stakeholders - nuclear operators, regulators, international organizations, and policy experts. Creating a forum to bring all relevant and responsible stakeholders together for periodic, candid discussion would provide a vital information input to advance nuclear governance and safe and secure plant operations. This dialogue, for example, could be sponsored and facilitated by the past or future NSS host country.

Recommended Actions

There are several actions that states could take in advance of the 2014 Nuclear Security Summit, either individually or collectively:

1. Agree to assess how to incorporate elements of the nuclear safety regime (e.g. regularized assessments, information sharing, peer review, reviews of the implementation of relevant international conventions, and strong trade organizations) into the nuclear security regime over time.

2. Acknowledge that barriers such as national sovereignty, lack of information transparency, lack of policy consensus, and regime harmonization are significant challenges and need to be addressed.

3. Seek an optimal balance between mandatory international standards and voluntary actions and/or endorse consideration of additional binding and non-binding international safety and security requirements.

4. Support strengthened independence of nuclear regulatory authorities in all nations, harmonization of accident/incident reporting parameters and expansion of information sharing and transparency in a crisis, incorporation of security as a fundamental element in new reactor designs, and robust protection of nuclear facilities, including against cyber attack.

5. Encourage civilian nuclear operators and regulators to engage with their foreign counterparts on nuclear security best practices while protecting sensitive information, particularly through the World Institute for Nuclear Security (WINS), and encourage regularized dialogue and interaction among nuclear operators, regulators, international organizations, and policy experts.