VIEWPOINT: PROMOTING NUCLEAR COOPERATION IN EAST ASIA: SAFETY, THE ENVIRONMENT, AND NONPROLIFERATION

by John N. Olsen & Richard C. Lincoln[1]

The vigorous growth and wide interest in nuclear power in East Asia reflect the region's rapidly expanding energy needs and its desire to sustain current economic growth trends.[2] However, the expansion of the region's nuclear industries raises central issues regarding regional nuclear safety, environmental protection, and nuclear proliferation.[3] Safety and environmental concerns about radiation releases arise principally from nuclear reactor operations, enrichment of uranium for fuel, and disposal of spent fuel (or other wastes) from the reactor fuel cycle. Nuclear material transport and other activities, such as mining and fuel rod fabrication, also have potential environmental impacts.

Reprocessing of spent fuel to separate plutonium for further use in reactors, that is, the "closed fuel cycle," introduces proliferation concerns, as well as safety and environmental issues. While the goal of separating the plutonium that is created in a uranium-fueled reactor may be further energy production, the separation of plutonium from other reactor waste products also provides a supply of material that has nuclear weapons potential.[4] Accumulation of separated plutonium, even under the inspection regime of the International Atomic Energy Agency (IAEA), presents the difficult problem of accounting for tons of material[5] with a very high accuracy. This difficulty is so great that many regard the closed fuel cycle as a threat to meeting nonproliferation goals.[6]

Concerns about regional nuclear activities interact with other sources of tension.[7,8] These include the confrontation between South and North Korea over the destiny of the Korean people, disputes over off-shore resources in the South China Sea, relations across the Taiwan Straits, and questions related to the ownership of various islands.[9] In addition, competition over fisheries and the effects of growing regional pollution are pervasive. A history of conflict dating back more than a century and a general lack of experience in crafting *cooperative* solutions to regional problems[10] complicate resolution of these issues.

Regional or bilateral cooperation might reduce tensions that are likely to arise from the expansion of national nuclear activities. In Northeast Asia, where the industry is well-developed, cooperation in the "back end" of the nuclear fuel cycle could help deal with storage and disposition of spent nuclear fuel. In Southeast Asia, where countries are just beginning to introduce nuclear technology, cooperation could be useful in developing regulatory structures for their nuclear industries. Throughout East Asia, cooperation could enhance operational safety and environmental protection and demonstrate the peaceful intentions of nuclear activities.

This essay enumerates several opportunities for cooperation on nuclear issues—including document exchanges, visits, and exchanges of technical information—that could ease tensions arising from the rapid growth of nuclear activities in the region. Implicit in these suggestions is the belief that nuclear cooperation can help build regional experience in cooperative mechanisms that may be helpful in solving non-nuclear problems as well.

Various cooperative measures could help reduce concerns about nonproliferation, nuclear safety, and environmental protection. As discussed below, information showing that reactors or nuclear materials are adequately protected could bolster confidence regarding nonproliferation compliance. Information showing that reactor operators are adequately trained, that safe procedures are routinely followed, and that reactor output is stable can all help build confidence in safety. Finally, environmental measurements at nuclear facilities or throughout the region could be exchanged to show that radioactive emissions are within prescribed limits; technical exchanges on the measurement technologies themselves could help establish environmental credibility, even with-

John N. Olsen and Richard C. Lincoln are Senior Members of the Technical Staff at Sandia National Laboratories, Albuquerque, New Mexico. Dr. Olsen is associated with the Cooperative Monitoring Center (CMC) and Dr. Lincoln is in the Arms Control Studies Department.

out the exchange of actual data. Some of the data exchanges noted below could address more than one concern: environmental protection may be another aspect of reactor safety, for example. Following a brief survey of East Asia's nuclear industries, the essay describes these and other cooperative opportunities in more detail.

EAST ASIAN NUCLEAR INDUSTRIES

The current status of nuclear industries in East Asia can be summarized as follows[11] :

- *Japan*—Japan has invested heavily in the nuclear power industry and generates one third of its electricity in 51 reactors. Over the next dozen years Japan expects to increase its nuclear power capability by 60-75 percent.[12] Energy security is an important stated goal[13] ; consequently, Japan maintains research efforts in the plutonium fuel cycle. Although Japan has renounced the development of nuclear weapons, other states have expressed concern about present and future accumulations of separated plutonium, which Japan has earmarked for future reactor fuel.[14]
- *China*—Although a nuclear weapons state, China has only three power reactors operating and two more under construction. With near-term plans to build four more reactors of French and Russian manufacture, China has announced plans[15] for a ten-fold expansion of its nuclear power generation over the next 15 years. China is also considering expansion of its plutonium fuel cycle research facilities.[16]
- *South Korea*—With 10 reactors operational and eight more under construction, South Korea is pursuing nuclear energy vigorously. As part of the 1992 "Joint Declaration for a Non-Nuclear Korean Peninsula" with North Korea, South Korea has renounced enrichment and reprocessing facilities.[17] South Korea will be heavily involved in the supply of two light water reactors (LWRs)[18] to North Korea under the 1994 Agreed Framework between the United States and North Korea.[19] The reactor project will be administered by the Korean Peninsula Energy Development Organization (KEDO) with involvement of Japan, the United States, the European Union, and other Asian countries in KEDO. The Korea Electric Power Company (KEPCO) will be the principal supplier and the reactors will be of the South Korean "standard" design.
- *North Korea*—In exchange for the promise of two LWRs, North Korea has suspended construction of two gas-cooled, graphite reactors and terminated operations of a reprocessing plant and associated research reactor. Provisions for safe operations and material protection at the new reactors are included in the Agreed Framework. The recent agreement to store 60,000 drums of low-level radioactive waste from Taiwan in exchange for $227 million has aroused controversy. Neighboring states, particularly South Korea, remain concerned about both environmental and proliferation issues, even as North Korea begins construction of the underground disposal sites.[20]
- *Russia*—Most of Russia's nuclear industry is in Europe and Central Asia,[21] but the Far East nuclear navy is based near Vladivostok. Dumping of low-level nuclear waste into the Sea of Japan (East Sea) has been a concern previously.[22] Also, there are four, small reactors far in the North at Bilibino that are of concern to Canada and Alaska.[23] Other planned facilities, such as a floating nuclear reactor scheduled to be built near Pevek on the Chukotka Peninsula, raise additional worries.[24]
- *Taiwan*—The vigorous growth of nuclear power on Taiwan has recently led to a controversial agreement (mentioned above) to dispose of low-level wastes in North Korea.[25] The Taiwanese nuclear industry is one of the first to find the "back-end" of the fuel cycle in danger of choking the "front-end." This may be an important precedent. Shipments of the 60,000 drums of waste to North Korea could begin in the fall of 1997, pending final approvals by the Taiwan Atomic Energy Council.[26]

Plans for growth in Asian nuclear power, noted above, would maintain a vigorous international industry in Asia, Europe, and perhaps the United States.[27] Nearly all of this growth is expected to be in LWRs, where generic similarity will help make cooperative measures more feasible. Gaining public acceptance[28] through safety and environmental protection will become increasing important for new facility sitings; this may be a strong factor to encourage cooperation in the region.

The states of Southeast Asia and Australia are preparing the technical basis on which to build nuclear industries. Indonesia, Malaysia, the Philippines, Thailand, Vietnam, and Australia are all operating research reactors currently. Technical interactions between the developed, Northeast Asian states like Japan and South Korea, and their Southeast Asian colleagues would both accelerate the development process and set precedents for regional cooperation that would be important in the years to come.

In fact, a number of regional interactions on nuclear issues are already taking place. These range from training exchanges sponsored by the more advanced states to participation in environmental monitoring of the Sea of Japan (East Sea). Several states are considering sharing information from their nuclear facilities; some exchanges of radiation data are already in place. Of course, the KEDO reactor project will involve close working relations between the nuclear experts of South Korea, North Korea, Japan, and the United States.

POTENTIAL COOPERATIVE MEASURES ON NUCLEAR ISSUES

Northeast Asian nuclear industries are vigorous, comprehensive, and modern. However, potential problems with proliferation, safety, and the environment have raised a number of concerns. These may be summarized as:

- *Nuclear Facilities*—concerns about nuclear material protection, operational safety, or environmental protection;
- *Material Control*—concerns about safety of fuel shipments, long-term storage of spent fuel and waste, and accumulations of plutonium; and
- *Regional environmental protection*—concerns about the release and transport of air- and water-borne radioactivity, an inherently international problem.

For Northeast Asia, cooperative opportunities hold the greatest promise at LWRs, which will be the basic technology of nuclear power generation. Two of the states, South Korea and North Korea will have LWRs of the same design (originally by ABB Combustion Engineering in the United States). China, Japan, and Taiwan have generically similar, pressurized water reactors that present closely similar monitoring options. Finally, Russia has four smaller graphite-moderated reactors in Siberia far to the North; although of dissimilar technology, the plant operators have shown interest in international cooperation. In Southeast Asia, the widespread operation of research reactors offers the possibility of cooperative activities encompassing those states as well.

The following analysis explores opportunities for information-sharing about nuclear facilities to show that nuclear materials are protected from loss, that operations are safe, and that the environment is protected. It presents most specifically a concept for regional collaboration to monitor airborne radiation levels. The purpose would be to begin development of regional capabilities to monitor environmental safety and to support regional emergency preparedness. This approach to building nuclear cooperation may be feasible because the countries of Northeast Asia already have many of the necessary technologies in place for their own internal environmental monitoring programs.

Cooperative Measures at Civilian Nuclear Facilities

Various analytical frameworks can be used to evaluate options for sharing information on nuclear facilities.[29] When assessing options for sharing information on a particular topic - material protection, operational safety, or environmental protection – the following questions must be addressed: 1) what information is relevant? 2) what are the best methods for sharing the information (e.g., document exchange, site visits, or remote monitoring)? and 3) what are the benefits and costs of sharing the information? The scope of information sharing is another aspect of the process. Information may be shared within a single facility, among multiple facilities within one country, or among multiple countries. Improving internal information exchange within a single country may be a practical first step that allows local technical experts to become familiar with new technologies before embarking on external collaborations.

Starting with material protection, we consider the relevance, methods, benefits and costs for cooperative measures in each of the topics.

Material Protection

Material protection cooperation involves sharing information that could build confidence that nuclear materials are safe from theft, diversion, or accidental loss. Confidence in material protection can address concerns about nuclear proliferation and potential nuclear terrorism.

Loss of nuclear material could occur during any access to the material. Thus, information regarding opportunities for access to material is relevant to material protection. In a pressurized, light water reactor (LWR), for example, access to in-reactor fuel can occur only during refueling. After removal from the reactor, the spent fuel may be vulnerable during shipment or short-term storage; finally, long-term storage poses another potential opportunity, particularly because the cooled fuel rods are less hazardous. Information about the design and power generation history of the reactor, and all movements of nuclear materials is relevant to material protection cooperation.

Protective measures are already in place at most facilities.[30] While the details of these procedures might be sensitive, the general requirements for protection of facilities and shipments would be relevant and could be shared.[31] International Atomic Energy Agency (IAEA) safeguards are designed to detect loss or diversion of nuclear materials by specifying material accounting procedures.[32] Safeguards inspection results are normally held as confidential; however, selected IAEA documentation could be relevant and might be shared, subject to IAEA approval.

Because extensive documentation is required in material protection, cooperative measures could focus on exchanges of: 1) records of storage or shipping; 2) notifications of refueling or other material movement activities; or 3) certain IAEA documentation (after modification of the IAEA Facility Agreement).

Physical protection methods could be shared by documentation; however, exchanges of visitors who are expert in protective measures might be more effective. Such exchanges could both build confidence between countries and allow peer experts to share operational experiences that might improve protection performance.

Remote monitoring technologies can play a role in material protection cooperation. For example, in LWRs, normal operational data (such as power, temperature, or pressure) can show that unscheduled refueling is not occurring. These data could be shared by electronic means. Going beyond existing operational monitors, additional sensors could monitor access events by means of motion or tamper detection. The addition of event-activated video cameras can help operators assess the nature of activities that have been detected by the sensors.

Sandia National Laboratories has an international demonstration to show that these technologies can be useful to monitor and assess certain activities in nuclear facilities. The current cooperation in remote monitoring (see Table 1) involves nuclear facilities in numerous countries, with the IAEA as an observer.[33] The data obtained at these various types of facilities might prove useful in developing nonproliferation, safety, or environmental cooperation among nuclear-energy consumers.

The purpose of these tests is to show the effectiveness and cost savings that remote monitoring might offer as part of the IAEA safeguards system. The same technology could be useful in bilateral or regional exchanges, as well. Sharing this type of information could build confidence that nuclear materials are being appropriately protected and improve the protection of these nuclear materials. Lessons learned from sharing information about selected nuclear facilities can also have educational benefits for other nuclear or non-nuclear facilities that include hazardous or valuable materials.

The costs include direct economic expenses as well as the risks associated with the possible loss of physical security-related information. The risks associated with cooperation on protection technologies and methods may be modest. The risks associated with sharing information on actual material protection operations may be higher and merit careful consideration.

Operational Safety

Civilian nuclear facility accidents can have a region-wide impact through the release of radionuclides into air or water transport pathways. Operational safety cooperation involves sharing information that could build confidence that civilian nuclear facility operations are safe against such releases. Poor operational safety can manifest itself in a variety of ways (e.g., poor equip-

Table 1. Cooperating Countries and Facilities in Remote Monitoring Demonstrations

Country	Location	Facility type
Argentina	Embalse	Spent fuel storage, outdoor silos
Australia	Lucas Heights	Spent fuel storage, indoors
Finland	Helsinki	Airborne radioactive particle sampling
Germany	Ahaus	Spent fuel storage, indoors
Italy	Ispra	Laboratory for Containment and Surveillance
Japan	Tokai	JOYO research reactor
Sweden	Barseback	Light water power reactor
United States	Idaho National Engineering Laboratory	Nuclear material handling and storage
United States	Y-12 Plant, Oak Ridge, Tennessee	Excess fissile material storage

ment test performance, poor record keeping, messy housekeeping, and numerous reactor or turbine interruptions and extended outages).

Given these observations, information about regulatory oversight, self assessments, test and maintenance activities, safety functions and equipment, and the availability of back-up safety equipment is relevant to operational safety cooperation. This information could contribute to regional confidence that civilian nuclear facilities are being operated safely. Correction of any problems identified through cooperation could reduce the probability or consequences of accidental releases of radionuclides from these facilities.

Document exchange is an effective method of sharing certain types of information. Information from operational records includes unusual occurrence reports, test and maintenance records, and operational logs. Information from on-site inspections includes observations of test and maintenance activities, annual inspections, and occasional unannounced, focused inspections. Information from regulatory or oversight records includes operator recertification records, inspection reports, and requests for regulatory exceptions. The regulatory records could be reviewed to develop confidence that safety regulations are being followed and that the regulatory body is doing its job. This process could also identify regulatory or operational processes that need to be strengthened, leading to improved operational safety with less risk of accidents that could have regional impacts.

Informal visits and personnel exchanges are a second method of sharing information of a less quantitative nature. Visiting experts can evaluate by informal inspection such characteristics as housekeeping, maintenance, and staff competence that are key to operational safety.

Cooperative remote monitoring is a third method of sharing information. A broad range of information is measured routinely and displayed in the operators' control room at the reactor and could be shared electronically. Information about key safety functions and equipment include selected reactor and coolant systems status, containment status, effluent and meteorological data, and the availability of back-up equipment. It would be simple to communicate some part of this operational database by electronic means to other organizations as a cooperative measure that could function automatically. In fact, some countries have the capability to monitor these critical quantities at their national regulatory authority already.[34]

The benefits of sharing this information would be to develop confidence that appropriate regulatory and operational safety processes are being implemented and to identify regulatory or operational safety processes that need to be improved. The costs of sharing this information include the direct economic costs, as well as the consequences of losing some level of control over the shared information. These consequences include the potential for loss of control of propriety or security information.

Environmental Protection

Environmental cooperation involves sharing information that could build confidence that civilian nuclear facility operations are environmentally sound. More importantly, prompt dissemination of this information could help reduce the consequences of accidental releases of radionuclides to the environment.

The primary regional environmental issue associated with civilian nuclear facilities and operations is the release of radionuclides, not hazardous chemicals or thermal effluents. Thermal effluents or releases of hazardous chemicals tend to have mainly a localized impact; a release of radionuclides has the potential for a region-wide impact. Regional radionuclide transport can occur within airborne or waterborne pathways.

Given these observations, the following information may be relevant to regional environmental cooperation:

- radioactive effluents or accidental releases from civilian nuclear facilities or transportation operations, since these are the source terms for potential regional transport;
- water pathways with the potential to reach another country or the ocean and airborne pathways, since these pathways have a potential for regional transport; and
- information about and from airborne and waterborne radionuclide sensors, since these sensors can measure radionuclide concentrations within potential transport pathways.

Parties to a cooperative agreement could choose between various methods to share information. Document exchanges could be used for radionuclide inventories, transport pathways, or effluents from civilian nuclear facilities. Visits or personnel exchanges could be most useful for comparisons of the radionuclide transport models that are used for environmental calculations. Remote monitoring could be the most timely method for measuring effluents from facilities or for tracking the location and status of nuclear material shipments.

Different methods of sharing information have different characteristics. For example, sharing airborne radionuclide sensor information by mailing monthly documents between two or more organizations introduces a time delay of weeks to more than a month between the measurement time and the information availability time. Sharing airborne radionuclide sensor information by remote monitoring introduces a time delay of seconds to hours, depending on measurement and communication techniques. If one of the motivations for sharing the information is to provide early warning of a developing radiological emergency, the more timely, remotely monitored information would be more valuable. If the motivation for sharing the information is to evaluate predictive models, then the document exchange method would be adequate.

Shared information about effluents from and transport around civilian nuclear facilities could be used to model regional transport of effluents and evaluate if they could have a regional impact. The benefit is in focusing regional concern on facilities that have real potential for region-wide impact. In addition, information about effluents and transport parameters could be used to test model predictions by comparing them with observed airborne and waterborne concentrations at various locations. In this case, the specific benefit could be regional trust in the model.

Information about civilian nuclear material transportation operations could include packaging, radionuclide inventory, transportation routing, and transportation operations. Shared information about material transportation operations could be used to assess the risks and consequences of spills or leakages into air or water transport pathways and to evaluate the potential for regional air or water transport. In this case, the benefit would be a common understanding of what transportation operations, if any, involve regional risk. In addition, satellite communications could be used to track the location and status of nuclear material shipments around the world. Electronic exchange of this data could be a real-time cooperative measure.

Shared information could include design and sensitivity data regarding radionuclide sensors, as well as airborne and waterborne radionuclide concentrations for selected locations. Reactor facilities normally measure radiation within the closed loops of the facility, in the cooling loop discharges, and at selected sites around the facility. Air and water samples are commonly available in real time, whereas soil sample results are updated manually and less frequently. Shared information from the sensors could be used to provide early warning of a developing radiological emergency and to compare predictive models developed for emergency response management. The benefits of sharing such information include more prompt application of public health procedures and reductions in both public health impacts and economic consequences of a radiological emergency. The costs of sharing this information include the direct economic costs as well as losing control of the shared information, which may entail the potential for legal liability or political embarrassment.

These options for nuclear cooperation have emphasized measures that would focus on specific facilities. Another type of environmental measurement, which is not facility-specific, is also worth consideration: a wide-area, airborne radiation monitoring system that might be tied into a regional system. Such measurement systems are in common use already, which could allow cooperative efforts to focus on improvements, communications, and data applications.

Regional Radionuclide Monitoring

Airborne radiation is a fruitful area for environmental cooperation because of the obvious transborder impact of a nuclear accident anywhere in densely populated Asia. The data obtained would be useful for assuring public safety, countering unfounded rumors about nuclear accidents, and increasing the modest level of nuclear cooperation already present in the region. Moreover, airborne data can be acquired over considerable distances, which allows measurements that are useful, but not intrusive and not specific to a particular facility.

Technology to measure radionuclides in the air is available world-wide at varying levels of sophistication to support a wide range of potential regional goals. If the immediate goal is emergency warning and monitoring of routine emissions, then a simple measurement of the total number of gamma rays might be appropriate. These systems are inexpensive, may be solar-powered for remote fielding, and can include basic meteorological observations. Because the total gamma rate is adequate for public safety, but does not reveal any process details, such monitoring is not highly intrusive. Los Alamos National Laboratory (LANL) has fielded a system of this type in northern New Mexico as a local transparency measure to address community concerns about the safety of LANL operations.[35] The system features automatic, electronic reporting for Internet retrieval.

The Los Alamos system monitors gamma rays from airborne radionuclides with 16 stations around the laboratory and in the surrounding communities. Each station combines radiation data with local wind speed and direction, and possibly other meteorological quantities. The entire station is solar-powered and a small radio transmitter sends the data off every four hours. Thus, the station can be placed anywhere, without concerns about availability of electricity and telephone lines. Unique to this system is the idea of making the data available on the Internet for easy public access.

Measuring the energies of the gamma rays and associating them with specific radionuclides can yield much more information.[36] Portable units are widely available with moderate resolution of the isotopic species that are emitting gamma rays. Higher resolution is available by adding a refrigerated detector and a high flow air filtering system. These are laboratory quality devices that draw significant power and provide very detailed information.

Finally, at the very top of the scale are the radionuclide monitoring devices required for world-wide verification of the Comprehensive Test Ban Treaty.[37] These are essentially upgraded laboratory units: higher air flow, faster data sampling, automatic reporting, and 24-hour reliability.

Whatever detector system is selected, the key to regional cooperation in radionuclide monitoring will be in tying the system together with communications that are reliable and prompt. Given the relatively short distances involved within populated areas in East Asia, an effective public safety measure should feature automatic reporting of radiation levels and basic meteorological quantities like wind speed and direction, temperature, and pressure. If reports were forwarded to a regional facility where experts could meet to discuss the data, misunderstandings could be avoided and new cooperative undertakings could be discussed in that forum.

Countries may prefer to first exchange information by document, rather than automatic transmission. This will work satisfactorily for a cooperative project focusing on developing and testing of regional predictive modeling capabilities. However, if there were an emergency response component, parties should consider processes to accelerate information exchange whenever unusually high readings occur.

All East Asian states with nuclear facilities have some expertise in radionuclide monitoring. Of course, the states with nuclear power reactors have more comprehensive networks than those with research facilities only. A regional cooperative project could build on these capabilities. If countries are interested in developing better capabilities in radionuclide monitoring, but are not yet ready for regional cooperation, coordinated projects in individual countries could be a first step. The projects could also help establish the infrastructure needed for possible future regional cooperation.

CONCLUSION

The continued growth of nuclear industries in East Asia provides both challenges and opportunities for regional security and development. Potential threats to the nonproliferation regime, public safety, or the environment could affect regional security; in addition, a major accident could curtail the growth of nuclear power to the point of hindering economic development. At the same time, because of the common need for energy for development, nuclear issues may be excellent topics for bilateral or regional cooperation.

Cooperative measures are applicable to important nuclear topics: material protection, operational safety, and environmental protection. In this paper we have identified potential benefits from cooperation in each area and suggested a spectrum of possibilities to suit the goals of potential participants. Also, cooperating partners may choose from a variety of methods for sharing information.

Although there is some regional experience in cooperation, further analysis of policy and technical issues would be valuable. Issues to be addressed include:

- *Protection of security or proprietary information*—Nuclear power plants and associated facilities represent enormous investments in development and construction. Securing the facilities and related information from unauthorized access is a natural response on the part of administrative authorities. The value of cooperation in gaining public and regional acceptance, and also in building confidence between states in general, needs to be compared carefully to the risks in sharing selected information.
- *Concentration on technical goals*—Regional nuclear

industries have many dedicated and competent technical personnel who cooperate in tightly defined interactions on safety and international safeguards. Policy analysis is needed to show how the industry and the state could benefit by building on these interactions to address other nuclear issues.

• *Direct economic costs*—All cooperative measures will have some financial burden, whether they are administrative or technical in nature. These costs need consideration in the broader context of benefits to national security, public health or economic growth.

• *Technical obstacles*—Some industries have much less experience and depth in the technologies that might be useful in cooperative measures. This is not a fundamental problem, but rather, an opportunity for bilateral or regional cooperation in training and experience building. Organizations like the Cooperative Monitoring Center at Sandia National Laboratories conduct training courses and topical workshops and can collaborate on technical support.

Policy research centers and academia can perform essential services in addressing the first three issues just noted in each of the industry and government hierarchies. Nuclear cooperation needs policy analyses that articulate the benefits and costs that may accrue to security, safety and development through nuclear cooperation. Without this policy rationale, technical organizations would have neither incentive nor authority to consider a wide range of cooperative opportunities.

Current discussions on nuclear cooperation in Asia have established a understanding of energy and environmental needs and identified important regional issues. Regional management of selected aspects of the nuclear industry are features of current PACATOM[38] or ASIATOM[39] dialogues, for example. The comparative lack of regional experience in cooperative measures poses a problem for implementing cooperative measures that include regional management. One of the first tasks then is to identify and justify step-by-step, pragmatic cooperation that can help develop a foundation for broader measures.

Several of the measures suggested in this essay may qualify for building cooperation on nuclear issues. The information exchanges could be implemented step-by-step because they are useful at the local, national, and regional levels. They are pragmatic because they address actual concerns of nonproliferation, safety, and the environment.

As a specific illustration, consider a progression of cooperative steps in radiation monitoring in the environment. All nuclear industries perform this essential task, reporting measurements as required to their respective regulatory authorities. Collaborative exchanges could first improve the monitoring and reporting procedures, with an initial goal of strengthening the domestic regulatory process. Further development could focus on establishing a regional monitoring network that could provide a prompt warning in case of an accident. The data from such a network could be confined to official use for emergency preparedness, or it might be open to the public to build trust in the safety of the industry. Eventually, cooperation to exchange the isotopic species from radionuclide monitoring devices could give information on the sources of radiation at a level of detail that could be useful for nonproliferation. Thus, participants could choose each step of cooperation for an identifiable pragmatic benefit. Finally, participation in one step would make the next step easier as cooperative experience accumulated, but no step would be obligatory.

Further discussion of these and other nuclear cooperative measures should involve both policy and technical experts with the goal of selecting the most promising candidates and establishing politically acceptable rationales. While drawing upon the European (EURATOM)[40] or South American (ABACC)[41] experience in cooperation may be useful, realistic proposals must reflect the Asian approach to and experience in cooperation. Regional fora, such as the Council for Security Cooperation in the Asia Pacific (CSCAP)[42] and the Northeast Asia Cooperation Dialogue (NEACD),[43] are already active in these discussions. Bilateral or sub-regional cooperative discussions may also be useful, and given fewer participants, may be more effective in selecting and implementing appropriate measures.

[1] 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. The Cooperative Monitoring Center helps political and technical experts from around the world acquire the technology-based tools they need to participate in arms control, nonproliferation and other security measures.

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[18] Fuel in light water reactors cannot be accessed during power production; hence, these are regarded as more proliferation resistant than the graphite reactor that North Korea was constructing.
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[27] Gregg. D. Renkes, "Nuclear energy in the United States: Is there a vision? Is there a future?" presented at the US-Japan Nuclear Energy Futures Workshop with Los Alamos National Laboratory.
[28] In his presentation, "Japan's Long Term Nuclear Program and Recycling Policy," Ruo Ikegame stated, "Recovering the confidence of the people in nuclear energy, damaged through accidents at 'Monju' and the Tokai Reprocessing Plant, is an urgent task of the first priority." *Ibid*.
[29] For one, see Richard C. Lincoln, "Potential Cooperative Measures for Civilian Nuclear Facilities: An Example Analysis Linking Policy or Agreement Goals to Specific Information to Share," Sandia National Laboratories (http://www.cmc.sandia.gov/issues/papers/lincoln1/index.html).
[30] See for example *The Convention on the Physical Protection of Nuclear Material*, International Atomic Energy Agency, Vienna, INFCIRC/274/Rev.1, May 1980 or electronically (http://www.iaea.or.at/worldatom/infcircs/inf274r1.html).
[31] The United States regulations for physical protection are *Physical Protection of Plants and Materials,* Code of Federal Regulation 10 (Washington D.C.: Office of the Federal Register), Part 73.
[32] Key safeguards definitions and practices are contained in *The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, International Atomic Energy Agency, Vienna, INFCIRC/153(corrected), 1983 or electronically (http://www.iaea.or.at/worldatom/infcircs/inf153.html).
[33] *International Remote Monitoring Project Plan: March 1996.* For information on this report contact Don Glidewell, Sandia National Laboratories, P.O. Box 5800, Albuqeruque, NM 87185-1213.
[34] For example, U.S. regulations for national monitoring are detailed in *Emergency Response Data System,* Code of Federal Regulations 10 (Washington D.C.: Office of the Federal Register), Part 50, Appendix E, Section VI.
[35] Larry D. Sanders, *Neighborhood Environmental Monitoring Station*, Los Alamos National Laboratory, LA-UR-93-3406 (1993). Current data and technical information are available at (http://newnet.jdola.lanl.gov/).
[36] Colin G. Sanderson, Norman Latner and Richard Larsen, "Environmental Gamma-Ray Spectroscopy at Remote Sites with Satellite Data Transmission," *Nuclear Instruments and Methods in Physics*, A339 (1994), pp. 271-277.
[37] L. R. Mason, *et al.*, *Radionuclide Monitoring Operations Report of the Prototype International Data Center: Third Quarter CY1996*, Pacific Sierra Research, PSR Technical Report 2682, Dec. 1996. Current status of the technology and test data are available at http://www.cdidc.org:65120/web-gards/#documentation. See also: S. M. Bowyer, *et al.*, "Automated Particulate Sampler for Comprehensive Test Ban Treaty Verification (DOE Radionuclide Aerosol Sampler/Analyzer)," *IEEE Transactions on Nuclear Science* 44 (June 1997), pp. 551-556.
[38] Robert A. Manning, "PACATOM: Nuclear Cooperation in Asia," *The Washington Quarterly* 20 (Spring 1997), pp. 217-232.
[39] Tatsujiro Suzuki, "Lessons from EURATOM for possible Regional Nuclear Cooperation in the Asia-Pacific Region (ASIATOM)," in *Energy and Security in Northeast Asia*, pp. 29-41.
[40] Darryl A. Howlett, *EURATOM and Nuclear Safeguards* (Macmillan, Basingstoke, 1990).
[41] The history of the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) is analyzed by John R. Redick, *Nuclear Illusions: Argentina and Brazil*, Occasional Paper 25 (Washington D.C.: Henry L. Stimson Center, December 1995).
[42] CSCAP was established in 1993 by over a dozen research institutes from 10 countries. For a history and current description of CSCAP activities, see the web page of the Research School of Pacific & Asian Studies, Australian National University, at http://coombs.anu.edu.au/Depts/RSPAS/AUSCSCAP/Auscscap.html#AbtC.
[43] For more information on NEACD, see the website of the University of California at San Diego's Institute on Global Conflict and Cooperation at http://www-igcc.ucsd.edu/igcc2/newsletterprev/newsletter/neacd4.html.