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Potential Cooperative Measures on Nuclear Issues in Asia*

John Olsen
Cooperative Monitoring Center
Sandia National Laboratories
Albuquerque, NM, USA

Introduction

Cooperation on nuclear issues is receiving increased attention in Asia. In Northeast Asia, where the nuclear industry is well-developed, cooperation in the "back end" of the nuclear fuel cycle could help deal with issues such as disposition of spent fuel and long term storage options. In Southeast Asia, where countries are just beginning to introduce nuclear energy, cooperation would be useful in developing standards for the nuclear industry. Throughout Asia, nuclear research and power activities can raise concerns about safety, environmental pollution and proliferation. The sharing of relevant information, i.e. cooperative monitoring[1], will be essential to addressing these issues.

We may summarize the nuclear status of the Asian states as the following:

- Japan - Japan has invested heavily in the nuclear power industry and generates one third of its electricity in 50 reactors. Energy security is an important stated goal; 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 plutonium, which Japan has earmarked for future reactor fuel.
- China - Although a nuclear weapons state, China has only three power reactors operating and two more under construction. However, in the past year China has announced plans for a ten-fold expansion of its nuclear power generation over the next 15 years. China is also considering expansion of their plutonium fuel cycle research facilities.
- South Korea - With 9 reactors operational and 7 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. South Korea will be heavily involved in the supply of two reactors to North Korea under the "Agreed Framework."

- North Korea - In exchange for the promise of two light water reactors, North Korea has suspended construction of a gas-cooled, graphite reactor and closed a reprocessing plant and associated research reactor. Safeguards against material diversion and provisions for safe operations are included in the agreement under the auspices of the Korean Peninsula Energy Development Organization (KEDO). The recent agreement to store low level radioactive waste from Taiwan has aroused further controversy. Neighboring states remain concerned about both environmental and proliferation issues.
- Russia - Most of Russia's weapons and power reactor industries are in Europe and Central Asia, but the Far East nuclear navy is based at Vladivostok. Dumping of low level nuclear waste into the Sea of Japan (East Sea) has been a concern previously. There are also four reactors far in the North that are of concern to Canada and Alaska.
- Taiwan - The vigorous growth of nuclear power on Taiwan has recently led to a controversial, landmark agreement to store low level wastes in North Korea. Taiwan is one of the first states to find the "back-end" of the fuel cycle in danger of choking the "front-end." This may be an important precedent.

The states of Southeast Asia 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, North Asian states like Japan and South Korea, and their Southeast Asian colleagues will both accelerate the development process and set precedents for regional cooperation that will be important in the years to come.

In fact, a number of regional interactions on nuclear issues are already occurring. These range from training exchanges sponsored by the more advanced states to participation in environmental monitoring of the East Sea (Sea of Japan). 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 U.S.

Potential Applications for Cooperative Monitoring in Nuclear Issues

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

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

In the following, we will explore opportunities for sharing information about nuclear facilities to show that operations are safe, the environment is protected, and nuclear materials are protected from loss.

For Northeast Asia we highlight opportunities at light water reactors (LWRs), which are 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 Combustion Engineering in the U.S.). 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 wide-spread operation of research reactors offers the possibility of cooperative activities encompassing those states as well.

We will conclude with a concept for a 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

We have developed an analytical framework for evaluating options for sharing information on nuclear facilities, as shown in Figure 1:

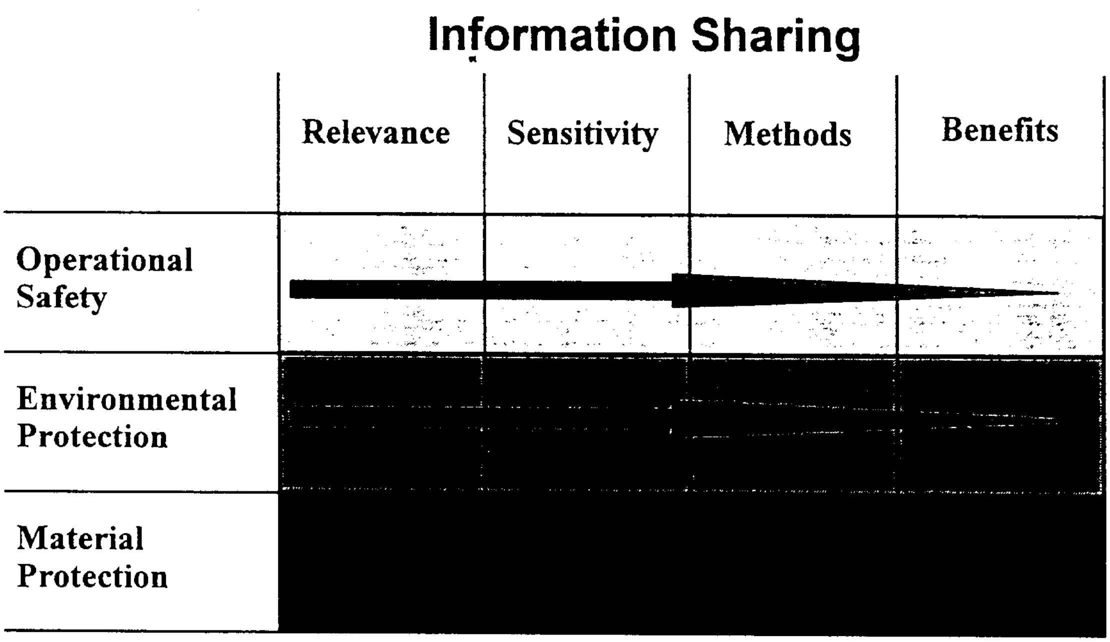

Figure 1. A framework for evaluating options for sharing information from nuclear facilities.

When assessing options for sharing information on a particular topic - operational safety, environmental protection, or material protection - we need to address the following questions:

1) What information is relevant?

2) Can this information be shared, or is it too sensitive for proprietary or security reasons?

3) What are the best methods for sharing the information, e.g., document exchange, site visits, or remote monitoring?

4) What are the benefits of sharing the information?

Information may be shared within a single facility, among multiple facilities within one country, or among multiple countries. In fact, we may find that 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.

Operational Safety

Operational safety cooperation involves sharing information that could build confidence that civilian nuclear facility operations are safe. The following discussion will identify the relevant operational information, suggest ways to share the information, and illustrate how shared operational data could be used.

Civilian nuclear facility accidents can have regional impact through the release of radionuclides. Overall poor operational safety can manifest itself in a variety of ways, e.g. poor equipment 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 being watchful. This process could also identify regulatory or operational processes that need to be improved, 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 monitoring is a third method of sharing information. A broad range of information is measured routinely and displayed at 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, many countries monitor these critical quantities at their national regulatory authority already.

Environmental Protection

Environmental cooperation involves sharing information that could build confidence that civilian nuclear facility operations are environmentally sound. Moreover, prompt dissemination of this information could help reduce the consequences of accidental releases of radionuclides to the environment. The following discussion will identify the relevant environmental information, suggest ways to share the information, and illustrate how shared environmental information could be used.

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 a release of hazardous chemicals tend to have local impact; a release of radionuclides has the potential for regional impact. Regional radionuclide transport can occur with airborne or waterborne pathways.

Given these observations, *information about radioactive effluents or accidental releases from civilian nuclear facilities or transportation operations* is relevant to regional environmental cooperation since these effluents or accidental releases are the source term for potential regional transport. *Information about and from airborne and waterborne radionuclide sensors* is relevant to regional environmental cooperation since these sensors can measure radionuclide concentrations within potential transport pathways.

Information that could be shared includes the location, inventory and chemical species of radionuclides in the facility. Similar information for effluents from the facility would be of interest. 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. In addition, this 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 models used by the respective national authorities.

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 risks of, or bound consequences of, spills or leakages into air or water transport pathways and to evaluate the potential for regional air or water transport. For this case the specific benefit could be a common understanding of the risks involved in transportation operations. In addition, satellite communications can 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 as well as used 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 and economic consequences of a radiological emergency.

Other facilities, like fuel fabrication, waste vitrification, and reprocessing plants and research reactors, all monitor radiation at critical locations around the site and within the neighboring areas. Exchanges of information that would not be directly comparable could also be proposed for these facilities. While seemingly more difficult, the benefit would be that more states could participate in the cooperative process.

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 was to provide early warning of a developing radiological emergency, the more timely, remote monitored information would be higher value information. If the motivation for sharing the information was to evaluate predictive models, then the document exchange method would be adequate.

After considering cooperative measures in nuclear material protection in the next section, we will return to environmental opportunities for a final concept. There, we consider wide-area, airborne radiation monitoring that might be tied into a regional system.

Material Protection

Material protection cooperation involves sharing information that could show 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. In this section we outline the relevant information and how it might be shared.

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, for example, access 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.

Protective measures are already in place at most facilities. While the details of these procedures might be sensitive, the *general plans for protection of facilities and shipments* would be relevant and could be shared. International Atomic Energy Agency (IAEA) safeguards protect nuclear materials by specifying material accounting procedures. Safeguards inspection results are held as confidential normally; however, the *IAEA reports* would be relevant and might be shared subject to IAEA approval.

Access to facilities and material movements during access would certainly be relevant to material protection. Some of this information may also be sensitive; however, cooperation on the technology to monitor access and material movement, as noted below, may be possible.

Because documentation is required extensively 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 Safeguards 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.

Monitoring technologies can play a role in material protection cooperation. For example, in reactors 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, movement 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. At Sandia we have an international demonstration to show that these technologies can be useful to monitor and assess certain activities in nuclear facilities. The current cooperation involves nuclear facilities in Europe, Asia, South America and the U.S. A laboratory in Japan is participating now and the Korea Atomic Energy Research Institute (KAERI) is considering a future role.

These options for nuclear cooperation have emphasized measures that would focus on specific facilities. In our final section we consider an environmental measure that does not have to be at a particular facility. The measurement systems are in wide use already, which could allow cooperative efforts to focus on improvements, communications and data applications.

Regional Radionuclide Monitoring

Airborne radiation is a candidate topic 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 safety of the public, 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 regional 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 has fielded a system of this type in Northern New Mexico as a local transparency measure to address community concerns about the safety of Laboratory operations. The system features automatic, electronic reporting for Internet retrieval; the station in Fig. 2 is typical of the technology.

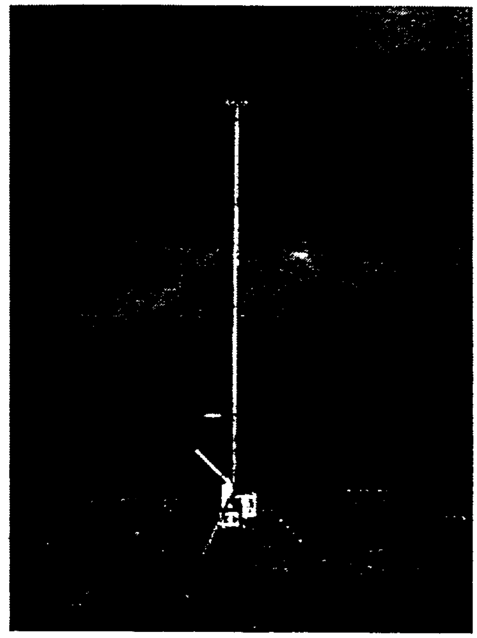

Fig. 2. A solar-powered gamma-ray measurement station near Los Alamos

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 4 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. 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 the world-wide International Monitoring System of the CTBT. 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 short distances involved, 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 regional predictive modeling capabilities. However, if there is an emergency response component, parties should consider processes to accelerate information exchange whenever unusually high readings occur.

All 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.[2]

Acknowledgment

Richard Lincoln, Sandia National Laboratories, Albuquerque, initiated the study of cooperative measures at facilities and formulated the framework discussed in connection with Figure 1. His full study is available separately.

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1.We define cooperative monitoring as the collection and exchange of agreed information among parties to an agreement. Technologies used for cooperative monitoring must be available to all parties; all parties must receive equal access to the results of cooperative monitoring.
2. The CMC would be happy to work with Northeast Asian countries as they assess their options for nuclear cooperation. We can help define technical options for exchanges and the associated cooperative mechanisms. For more information please contact John Olsen at (505) 284-5052, fax (505) 284-5055, or e-mail to jnolsen@sandia.gov.