**Goals of Nuclear Power Plant Operators' Risk Assessment and Management Activities in Japan**

Shunsuke Kondo, Chairman
Japan Atomic Energy Commission

Good morning, distinguished delegates, ladies and gentlemen. It is a great pleasure for me to present you my thought on the goals of nuclear power plant operators' risk assessment and management activities in Japan.

Before I begin, I want to extend a special greeting to those of you traveled to participate this gathering and my dear friends, George Apostolakis and John Garrick, in particular, for giving us especially enlightening talks on the PRA.

After the unprecedented severe accident at the Fukushima Daiichi, various accident investigation teams were organized and they published their judgment on the causes of the disaster and lessons they learned from it in succession. Among them, the National Diet of Fukushima Nuclear Accident Independent Investigation Commission (NAIIC) provided the results of a somewhat different perspective from others, focusing on a governance process perspective. I will assume that everyone in this room is generally familiar with the commission's verdict. Therefore I will skip right to the four conclusions that anchored my views on post-Fukushima actions related to PRA applications.

1. The root causes of the accident were in the organizational and regulatory systems that supported faulty rationales for decisions and actions. Therefore the accident was clearly "manmade."
2. There were organizational problems that limited an effective emergency response in the utility such as insufficient level of knowledge, training, and emergency procedures related to severe accidents.
3. The nuclear power plant operator did not fulfill its ultimate responsibility for the safety of his facility, relying on the regulators taking final responsibility. This relationship weakened the pursuance of minimizing risk in line with the principle of as low as reasonably practicable (ALARP).
4. Laws and regulations related to nuclear safety have only been revised as stopgap measures when an accident happened: the latest technological findings from international sources have not been reflected without delay in existing nuclear energy laws and regulations. What must be admitted - very painfully - is that this disaster was 'Made in Japan'.[1]

[1] The NAIIC pointed out that its fundamental causes are to be found in the ingrained conventions of Japanese culture: our reflexive obedience; our reluctance to question authority; our devotion to 'sticking with the program'; our groupism; and our insularity.

Based on these conclusions, the commission recommended fundamental reforms of both the structure of the electric power industry and the structure of regulatory agencies as well as their operation processes, pointing out the elimination of insular attitude of ignoring international safety standards, in particular.

The National Diet amended Atomic Energy Basic Act, in response to this verdict, adding Clause 2 to Article 2, which specifies that the assurance of nuclear safety should aim at protecting people's life, health, property and environment and making for national security, with a full recognition of internationally established standards of safety, and Article 3.2 to Article 3, which specifies the establishment of Nuclear Regulatory Authority (NRA) as an extra-ministerial bureau of the Ministry of Environment (MOE).

The newly established NRA is now responsible to promote effective and efficient safety regulation, with a full recognition of international safety standards, maintaining an able team with right skill, experience, knowledge and behavior, and following the five principles of good regulation; independence, proportionality, accountability, consistency and transparency, and thereby enhancing confidence and trust of the public.

In July last year, the NRA established a set of new regulation rules that reflected lessons the NRA as well as international nuclear safety community learned from the accident at Fukushima Daiichi concerning the safety design of the reactor systems and the emergency preparedness and response arrangement to deal with a nuclear emergency caused by external events, without explicitly delineating risk management goals that aim at protecting people's life, health, property and environment, with a full recognition of internationally established standards of safety. The gist of it is from my viewpoint as follows:

A. Ensure that design base external events (seismic, seismic-tsunami and other events) are properly evaluated and reflected in the design: in this connection, all the nuclear operators have been asked to accelerate the survey and characterization of active faults around the site, including their interlock condition, based on the most up-to-date knowledge in seismology, including that obtained by detailed geological survey.
B. Satisfy the requirement 20, design extension condition of the IAEA safety design standard, covering extended losses of power and ultimate heat sink by providing a diverse and flexible alternative capability to supply power and cooling.
C. Ensure that severe accident management procedures including reliable hardened vents for specific reactor containments, which take into consideration of the fact that external events might affect the entire site, are in place so as to protect against broader societal and environmental harms.

Now, what actions should we expect nuclear operators to take, in response to the verdict of the NAIIC?

As you know well, towards the end of the previous century, nuclear operating organizations were faced with increasing needs for introducing new requirements and goals that included safety, health, environmental, security, quality and economic elements and other considerations such as social responsibility. As a result, a new management system was evolved to accommodate these needs and to ensure that the employees understand what has to be done to meet all requirements (based on the recognition that the daily practices and the results achieved by the organization, the organizational culture and the management processes were deeply interrelated).

This figure by K.D. Persson of the IAEA shows a simplified evolution over the last century regarding the key management approaches applied by organizations in order to achieve good safety standards and performance.[2]

The purpose of Quality Control activities was, as you know well, to make sure the results of what you've done are what you expected by inspection for yes or not acceptance. Then came the day of Quality Assurance approach, of which purpose was to make sure you were doing the right things in a right way, by employing measures to systematically prevent nonconformance such as established procedures and documentation to demonstrate that quality was implemented throughout the process.

The emergence of the Integrated Management System was the development where the organizations became increasingly aware that other stakeholders, apart form just their customers and employees, had to be addressed while conducting their business. Organizations put increasing attention on diverse goals and requirements as mentioned before and aimed to manage the totality of them by using an integrated management system that can deliver the vision of top management and the goals and objectives of the organization in a coherent, harmonious and optimal way.

Recognizing the importance of this evolution, the IAEA replaced the Code on Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations[3] with the Safety Guide GS-G-3.1[4] that provides generic guidance to aid in establishing, implementing, assessing and continually improving a management system for nuclear facilities and activities.

With regard to safety, the Guide specifies that the management system shall be used to promote and support a strong safety culture by reinforcing a questioning attitude at all levels

[2] K.D. Persson: IAEA Safety Standards on Management Systems and Safety Culture. Atom Indonesia **33**, 1 (2007)

[3] INTERNATIONAL ATOMIC ENERGY AGENCY: Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations, Code and Safety Guides Q1–Q14, Safety Series No. 50-C/SG-Q, IAEA, Vienna (1996).

[4] International Atomic Energy Agency: Application of the management system for facilities and activities: Safety Guide No. GS-G-3.1, IAEA, Vienna (2006).

of the organization and that organization's plans and objectives for safety should represent an ambitious picture of the future of the organization, in addition to a strong willingness to undertake continual improvement in other areas of performance, such as availability of products, costs, industrial safety and communication with interested parties, establishing a learning culture in the organization.

Measurement, assessment and improvement are essential activities for establishing a learning culture in the organization. The Guide recommends that to avoid any decline in safety performance, senior management should remain vigilant and objectively self-critical, promoting objective measurement and assessment activities as a key to this discipline.

The Guide recommends the use of performance indicators that provide valuable information in the effective management of plant performance. After TMI accident, nuclear operators in Japan had used performance indicators such as the unplanned automatic trip rate, number of defect fuel, plant availability, the unavailability of emergency diesel generators (EDGs) and had been proud of their high performance based on them.

Since the late 1980s, the IAEA has been actively sponsoring work in the area of indicators to monitor nuclear power plant operational safety performance. In the IAEA work[5], three key attributes were chosen that are associated with plants that operate safely: they are a) plants operate smoothly: b) plants operate with low risk; and c) plants operate with a positive safety attitude. Needless to say, probabilistic indicators such as core damage frequency (CDF) obtained by level 1 PRA, large release frequency (LRF) obtained by level 2 PRA and consequences-frequency relation obtained by level 3 PRA are dominant performance indicators to monitor the attribute plant operate with low risk.

In Japan, however, the activities to review the entire safety case including risk assessment of plant considering internal and external hazards have not been ranked properly in the safety management systems of Japanese utilities. Even though a review process that is refereed to Periodic Safety Review (PSR) has been carried out at the interval of 10 years under the guidance of regulatory authorities since 1994, the PRA submitted to the procedure had covered only internal hazards, even though there appeared significant progress in the seismology after Kobe earthquake, not to mention the appearance of pioneering seismic PRA activities in the Individual plant examination for severe accidents initiated by external events (IPEEE) submitted to the USNRC.

Why was the activity so superficial? Looking back on the behavior Japan has taken on regulating and managing risks, I couldn't help but point out that the emphasis has been on simply "addressing risk in some way". It mattered not what to do for safety or how to do for safety in most occasions!

[5] IAEA TECDOC-1141: Operational safety performance indicators for nuclear power plants (2000). The work recognized that focusing on any single aspect of safety performance is ineffective and can be misleading.

From my view point it is now a condition for survival for Japanese nuclear operators, however, to conduct thorough and deep risk analysis and use the process as an essential tool to ensure the fundamental requirement for nuclear power plant risks to be maintained as low as reasonably practicable (ALARP), though to do so is clearly their obligation in light of the revised Atomic Energy Basic Act and the revised Act on the Regulation of Nuclear Reactors. In the risk analysis, PRA should be used in the largest possible variety of situations to assess risks arising from any nuclear accident due to its facilities or to natural events. The risks should be periodically reviewed, taking into account changes over time such as new knowledge about the risk or the availability of new techniques for reducing or eliminating risks.

Why should I think in that way at this juncture? It is because the levels of risk to people that are acceptable is a combination of both individual risk and societal concerns and the levels of societal concern are very high after the severe accident at Fukushima. This requires nuclear operators to apply a very stringent risk control regime, both to reduce the level of individual risk and to assuage the societal concerns, such that the risk of long-term restrictions on the use of extensive areas of land and water, should a major accidental release of radioactivity occur due to rare yet credible events, is brought down to a very low level.

In addition, traditional paternalistic approach that government, corporations and associations have taken in the past in determining how involuntary risks should be addressed is no longer acceptable to society. People want to be involved or at least to have opportunity to be involved in decisions about how the risks to which they are involuntarily exposed are addressed in the context of ALARP principle.

As society wants that only institutions that are trusted should take such decisions, nuclear operators have to work hard to earn and maintain the trust of society. It is important for the senior management of nuclear operating organization to recognize that effective communication is the key to creating trust in risk management and to make an utmost effort to establish and sustain civic trust in its managers' and expert's competencies, communicating and explaining the rationale for the risk management decision so as to allow people to make informed decisions about the risk and the disaster management.

Now, some thought on PRA application to risk management. First, the results and insights from the risk analysis should be communicated to a wide range of the operating organization itself as they help people expand the number of undesired consequences they envision so that they can expand the number of precautions they will take. To avoid failure, you have first got to embrace it.

Second, based on the result and insight of PRA, operators should take all measures to reduce risk where doing so is reasonable. A straightforward approach to do so is to apply existing relevant good practice and international standards, as their development includes ALARP

considerations in many cases. In other cases where it is less evident that they are standard and relevant good practice, the operator should implement measures to the point where the costs of measures would be grossly disproportionate to the further risk reduction that would be achieved by them.

Third, PRA models that address the risk from nuclear power plants are complex models, the development of which involves the development of logic structures (e.g., event trees and fault trees) and the assessment of the frequencies and probabilities of the basic events of the logic structures. Such development and assessment make it possible to treat uncertainties in our knowledge explicitly, which need to be addressed in decision making. Risk managers should never make their large size as an excuse for indecision.

It is often proposed that when it is decided to introduce protection systems against highly uncertain hazards, you should pursue to make your system resilient so that it can withstand or even tolerate surprises. Specific approach to be proposed are increase in safety margins, diversification of the means for attaining identical or similar ends, pursuance of means to reduce the overall catastrophic potential, providing protection systems with flexible response options and improving the conditions for emergency management and system adaptation.

Though there is something to be proposed in such ways, it is prudent, before jumping to such proposals, to consult with the guidance given in NUREG-1855, Rev. 1 titled “Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decision-making”[6] that provides guidance on how to treat uncertainties associated with PRA in risk-informed decision-making. You might be reminded in your underestimation of uncertainties or find helpful hints for the selection among these candidates for resilience.

Fourth, the major challenge in the safety assessment for multiple-units site or nuclear facilities attacked by external events is to define the factual base for making risk management, overcoming the apparent complexity of the messy situation to be expected in such events. The interconnections and interdependencies among support systems and troubled systems must be taken into account in risk assessment, since these relationships can dramatically affect event consequences. It is highly recommendable to pursue the improvement in the reliability and validity of the results that are produced in the appraisal of risk of such complex situation, though it may sound like inconsistent with the description that the event is messy and complex.

---

[6] U.S. Nuclear Regulatory Commission, " Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decisionmaking”, NUREG-1855, Rev. 1 DFC Washington, D.C., March 2013. This NUREG (in association with Electric Power Research Institute (EPRI) report 1016737, “Treatment of Parameter and Model Uncertainty for probabilistic Risk Assessments” [EPRI, 2008] and EPRI 1026511, “Practical Guidance on the Use of PRA in Risk-Informed Applications with a Focus on the Treatment of Uncertainty” [EPRI, 2012] provide guidance on how to meet the PRA standard’s requirements for uncertainties.

With respect to managing such category of risks, the emphasis is usually placed on the improvement of the robustness in responding to whatever the troubled system is going to be exposed to. Measures to improve robustness include inserting conservatisms or safety factors as an assurance against unreliability of prediction of situation, introducing diverse safety devices to improve protection against multiple stress situations, reducing the susceptibility of the system to be protected, improving the organizational capability to initiate, enforce, monitor and revise emergency management actions quickly.

So far, I have expressed my recognition of the condition for nuclear operating organization in Japan to survive in post-Fukushima society, that is, striving for excellence and implement programs to continuously improve its safety performance. I sincerely hope therefore that operating organizations as a group should encourage this effort each other and reinforce it by using all possible synergies within the group in the framework of its common nuclear safety policy, establishing the Nuclear Power Plant Operators' Principles of Conduct that specifies norms of corporate self-management based on risk analysis for the safe operation of nuclear power plants. Some of the really big issues in risk management cannot be solved by individual organizations, however. Therefore you should seek guidance from standards organizations and professional organizations at home and abroad.

As risk analysis is to quantify its effects by modeling. In the execution of this activity, it is essential to adopt the language and the philosophy of modeling uncertain systems, which is scientific activity. The process of analysis and its application should be scientific process. With that in mind, I would like to close my talk by proposing that in order to continuously promoting successful risk management, nuclear operators should strengthen science and technology organizations (STO) that support good risk analysis by promoting activities to assure human resources and knowledge basis for performing scientific risk management by developing models, standards, data-basis and producing the state of the art PRAs steadily.

Thank you for attention.