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## KNOWLEDGE MANAGEMENT AND NETWORKING FOR ENHANCING NUCLEAR SAFETY

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Abstract. Striving for innovative solutions to enhance efficiency of programme delivery and a wider outreach of its nuclear safety activities, the International Atomic Energy Agency (IAEA) has developed an Integrated Safety Approach as a platform for linking its safety related statutory functions and its many associated activities. The approach recognizes the vital importance of effective management of the knowledge base and builds on the integration between the IAEA's safety standards and all aspects of the provision for their application, including peer reviews and technical meetings to share lessons learned.

The IAEA is using knowledge management techniques to develop process flows, map safety knowledge and to promote knowledge sharing. The first practical application was the establishment of a knowledge base related to safety aspects of ageing and long-term operation of nuclear power plants.

The IAEA is also promoting and facilitating the establishment of regional nuclear and radiation safety networks to preserve existing knowledge and expertise as well as to strengthen sharing and creation of new knowledge in these fields. Prominent examples are the Asian Nuclear Safety Network established in the frame of the IAEA's Programme on the Safety of Nuclear Installations in South East Asia, Pacific and Far East Countries, and the Ibero-American Radiation Safety Network in the frame of the Ibero-American Forum of Nuclear Regulators. Results to date are most encouraging and suggest that this pioneer work should be extended to other regions and eventually to a global nuclear safety network.

Responsive to the need of Member States, the IAEA Secretariat has prepared and made available a large number of up-to-date training packages in nuclear, radiation, transport and waste safety, using IAEA safety standards as a basis. It is also providing instruction to trainers in Member States on the use of these modules. This ensures that the material is properly used and that the IAEA receives feedback so that training services and material are improved and kept current. This approach adds a new dimension to transferring knowledge as compared with conventional training methods.

Recognizing that nuclear safety and security are truly global and transboundary issues, the IAEA has put forward the vision of a global nuclear safety and security regime that provides for the protection of people and the environment from effects of ionizing radiation, the minimization of the likelihood of accidents that could endanger life and property, and effective mitigation of the effects of any such events. The IAEA will pursue knowledge management and networking as fundamental elements for achieving this vision.

### INTRODUCTION

The nuclear industry worldwide has a high safety record and has shown substantial improvement over the past decades. Nevertheless, in the light of the accumulated nuclear power plant (NPP) operational experience, the sharing of information on significant safety improvements, best practices and lessons learned remains a key opportunity to ensure that *a safety improvement anywhere is a safety improvement everywhere*. This will meet the safety needs related to long term operation of the current fleet of NPPs and design and construction of new ones.

For the IAEA the challenge has been to enhance the effectiveness of the delivery and outreach of its nuclear safety activities within limited resources. Exploiting the rapid developments in information technology and the application of knowledge management tools, the IAEA has developed an Integrated Safety Approach (ISA) that establishes a linkage between the development and application of its safety standards, the associated feedback mechanisms and the strategic management of the comprehensive knowledge base created for this purpose.

To implement the ISA, the IAEA is, step by step, introducing process flows, identifying safety domains and mapping safety knowledge. A pilot project on safety knowledge management related to ageing and long term operation of nuclear power plants has been successfully implemented.

As an integral part of this approach, the IAEA is also promoting and facilitating the establishment of regional nuclear and radiation safety networks to preserve existing knowledge and expertise and to strengthen sharing and creation of new knowledge. Thus, application of state of the art knowledge management and networking reinforce each other.

Sustainable education and training is key to the safe utilization of nuclear energy and depends closely on the quality and usefulness of the knowledge base. Therefore, the IAEA is orienting its efforts to the development of standard training packages based on IAEA safety standards and training trainers at national and regional training centres.

#### INTEGRATED SAFETY APPROACH

Establishing nuclear safety standards and providing for their application are main statutory functions of the IAEA in the area of nuclear safety. To ensure the effective linkage between these functions and related activities, the IAEA has developed an integrated safety approach. The ISA provides a platform for continuous improvement using the feedback from safety reviews, education and training; technical cooperation projects, and coordinated research programmes. It also fosters information exchange through conventional means, such as conferences, workshops and technical meetings and facilitates the establishment of regional safety networks.

Central to the ISA is the efficient management of the associated knowledge base. Therefore, the IAEA is pursuing a vigorous knowledge management programme to elicit and preserve existing knowledge as well as to promote the creation of new knowledge.

Figure 1 depicts the ISA elements, including the feedback mechanism, the associated knowledge base and the networking to share safety knowledge among Member States.

The IAEA is using a similar approach for its nuclear security activities, but this is beyond the scope of this paper.

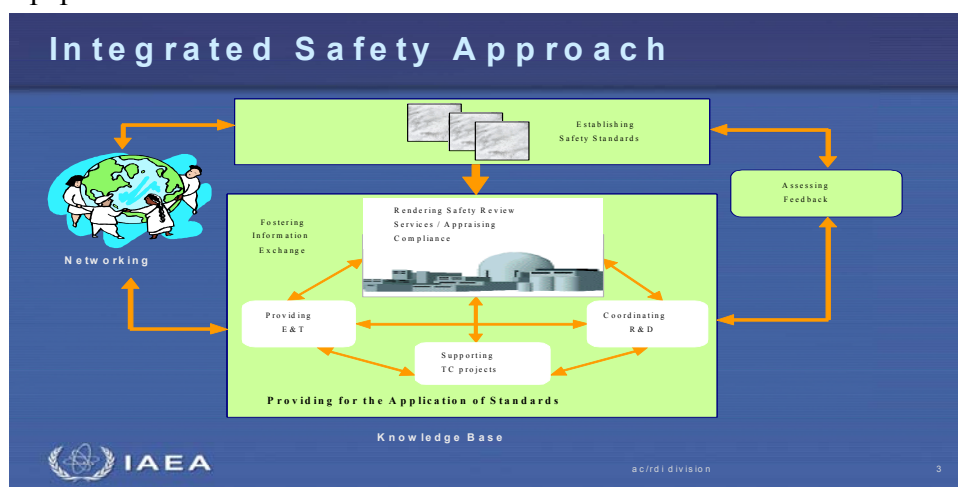


Figure 1. Integrated Safety Approach

## PRACTICAL APPLICATION OF KM METHODS

The IAEA's introduction of knowledge management methods into its Nuclear Safety Programme is following a planned, step-by-step process. This process takes into account that the Programme is primarily knowledge based and that nuclear safety knowledge, both thematic and process oriented, is an asset that needs to be elicited, classified, analyzed, preserved and networked for easy retrieval and mutual learning. Considering the needs of the nuclear safety community in Member States, the process identifies and retains relevant knowledge associated with the preparation and application of the IAEA safety standards. This includes results of safety reviews, coordinated research programmes and education and training activities. Implementation of the knowledge management system involves the following steps: the identification of knowledge domains and knowledge centers; the development of a knowledge taxonomy for codification; knowledge mapping and retention; and the development of a portal for knowledge retrieval and sharing.

The underlying concept for the long-term sustainability of the system provides for a decentralized yet interconnected operation with ownership and commitment from stakeholders at all levels, and cultivates an environment that values knowledge sharing and promotes its bottom-up application in both new and existing work routines.

A safety knowledge portal is designed for convenient access to existing and new knowledge related to the IAEA's nuclear, radiation, transport and waste safety activities. It includes thematic or subject related knowledge and process oriented knowledge.

Figure 2 depicts the basic structure being used for knowledge retention and retrieval. For each safety domain a knowledge base will be developed using a standard structure. The application of the structure to ageing and long term operation of NPPs is described in the next section.

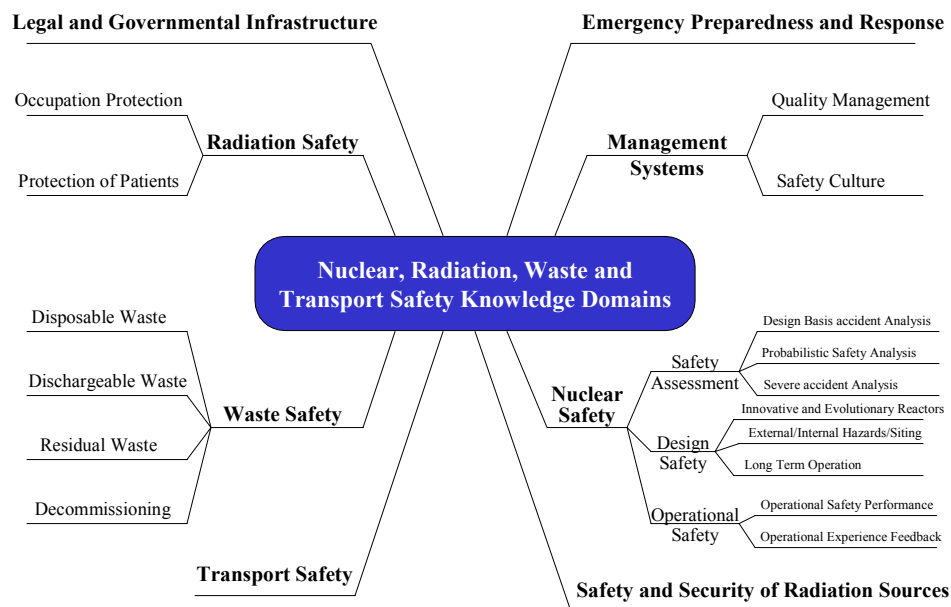


Figure 2 Safety Knowledge Structure

### 2.0. Safety Knowledge Base on Ageing and Long Term Operation (SKALTO)

SKALTO for NPPs is the first IAEA practical application of knowledge management techniques related to its nuclear safety programme. This technical area was chosen in 2002 for

a knowledge management pilot project because of the existence of a comprehensive guidance on effective management of physical ageing of NPP systems, structures and components important to safety which the IAEA developed in the 1990's [1]. References [2] and [3] provided the core for SKALTO's knowledge inventory.

The objective of SKALTO is to develop a framework for sharing of knowledge on safety aspects of ageing management and long term operation (LTO) of NPPs in order to help (a) IAEA Member States maintain high level of NPP safety and performance through effective ageing management and other LTO programmes and (b) IAEA staff increase the effectiveness of relevant activities. The scope of SKALTO is limited to the management of physical ageing of NPP structures, systems and components important to safety, and other LTO programmes, such as periodic safety review, configuration management, and design basis data management.

The goal of SKALTO is to identify and store relevant knowledge (or provide links to relevant knowledge sites) to facilitate its retrieval, updating, extension and dissemination to potential users and thus to promote more creative and effective ageing management and LTO programmes and activities. The key users include: IAEA staff; NPP operating, regulatory, technical support, design and supplier organizations; and research institutes and universities.

The basic structure of SKALTO is shown in Figure 3. It includes: sections of IAEA Safety Standards relating to ageing management and LTO; programmatic and component specific guidance on ageing management; national standards; results of ageing management and LTO safety reviews; lessons learned from operating experience; R&D results; as well as education and training materials.

SKALTO implementation is proceeding in phases to facilitate system testing, refinement, and a gradual increase in the knowledge inventory. Phase I, implemented on the IAEA intranet in January 2004, was limited to using readily available IAEA nuclear safety programme materials. A limited scope version is available to the public at:

<http://www-ns.iaea.org/projects/salto/default.htm>

In Phase II, the scope was increased to include additional IAEA material and improve ease of use. Phase III will include a full internet version and links to relevant web pages of other organizations. Beyond Phase III, work will include a development of an interactive portal system to facilitate communication among practitioners aimed at problem resolution, and a continuous improvement of SKALTO's knowledge base and its retrievability. SKALTO has appropriate confidentiality and security measures built in.

More information on SKALTO, including a demonstration of the Phase II prototype, will be available at the Poster Session of the conference.



Figure 3. Basic SKALTO Structure.

### 2.1. Process flows

Work is also underway on the development of process flows for process visualization and association of flow elements to knowledge domains. A particular application is related to the development of nuclear safety standards and other safety related publications. The development of IAEA safety standards is a complex process that involves specialized subject related knowledge and a large and diverse group of stakeholders in the review and approval process. Principal stakeholders are the IAEA and other technical experts drafting the standards, the specialized review Committees, the international scientific community represented in the review and comments of Member States, the Commission of Safety Standards that advises the Director General and, depending on the category of the standard, the IAEA Board of Governors.

Knowledge Management tools for process modeling are being explored to increase the effectiveness and efficiency of the IAEA's safety standards development process. Each step of the flow is analyzed with respect to the thematic and process knowledge involved. Knowledge intensive paths and tasks are identified, logical relationships among activities are displayed, and knowledge needed is elicited and associated to the knowledge domains.

Figure 4 is a much simplified presentation of basic elements and knowledge domains of the process flow for the development of IAEA safety standards.

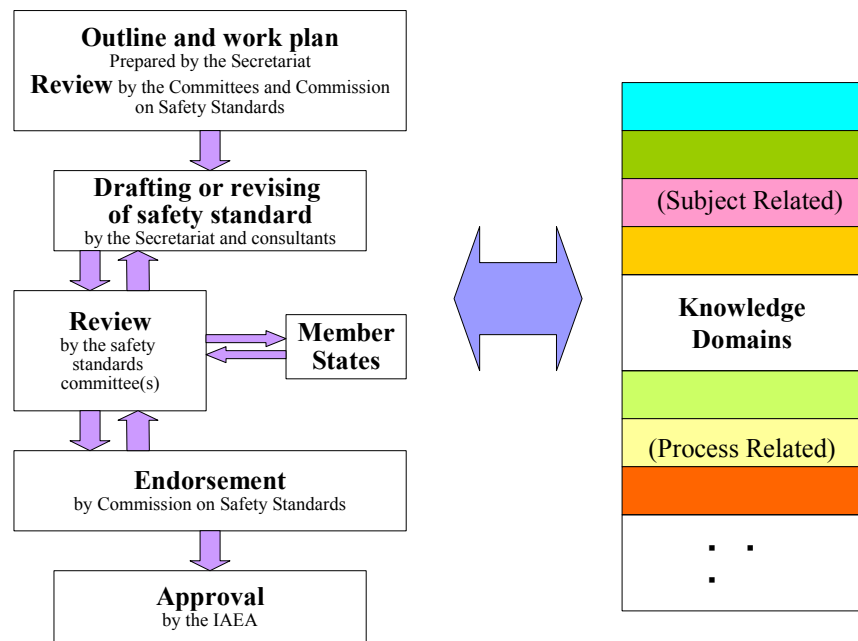


Figure 4.

#### Process Flow for the Development of IAEA Safety Standards

### NUCLEAR AND RADIATION SAFETY NETWORKS

Although there is a wealth of safety knowledge throughout the world, unless that knowledge is effectively compiled, analysed, shared and used by the scientific community, it will remain of limited value. Therefore, the IAEA is promoting and facilitating the establishment of regional nuclear and radiation safety networks to map, retain, share and create new knowledge in these fields. Prominent examples are the Asian Nuclear Safety Network, and the Ibero-American Radiation Safety Network.

#### 2.2. Asian Nuclear Safety Network (ANSN)

The ANSN was established in the frame of the extra-budgetary programme on the safety of nuclear installations in South East Asian, Pacific and Far East Asian countries. It started operation in 2004, after completing, in 2003, a pilot phase focused on education and training.

The network is operated in a coordinated yet decentralised manner with hubs in China, Germany, Japan and Korea (Republic of). Other countries participating in the ANSN are: Indonesia, Philippines, Malaysia, Thailand and Vietnam. In these countries, national centres are being established to host national knowledge and as portals to the ANSN. The establishment of national centres is also an essential step towards developing national networks for sharing safety knowledge among institutions and experts in each country. The IAEA is providing technical guidance and assistance to these initiatives.

The ANSN operation links web servers operating at the hubs and national centres with a master index hosted by the IAEA. This master index serves as a portal for users to interrogate and retrieve safety knowledge.

A taxonomy was developed for classification of technical knowledge related to NPPs, research reactors and fuel cycle installations. Documents and associated metadata are stored and maintained at the local web servers operating at the hubs and national centres and communicated to the master index database. The master index and the local databases are synchronized.

Users can search using the ANSN master index or the indexes maintained at each hub. Documents are retrieved directly from the local servers where they are stored.

The ANSN shares thematic knowledge associated with the work of four topical groups dealing respectively with safety analysis, education and training, operational safety and safety culture. The ANSN is also a portal for access to the data base maintained by the IAEA on results of the Extra Budgetary Programme. A group of information technology specialists from the IAEA and participating countries develops and implements the information technology solutions for the ANSN.

The ANSN is password protected and users may be granted different levels of access. A Steering Committee has been established by the IAEA to coordinate the development and operation of the network.

The ANSN structure is represented in Figure 5. More information on ANSN will be provided at a Poster Session of the conference.

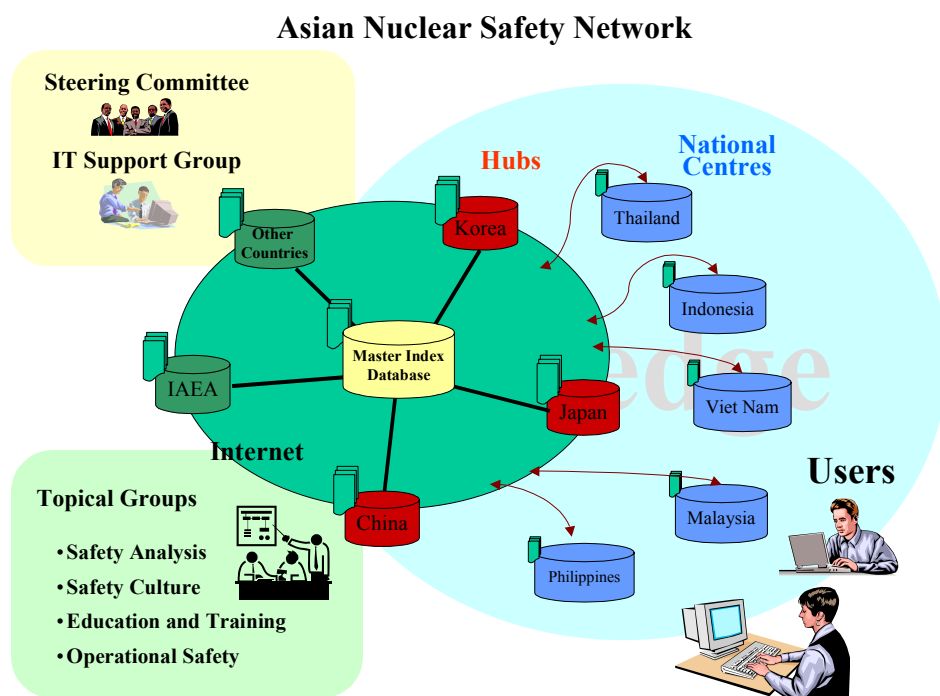


Figure 5. Asian Nuclear Safety Network.

### 2.3. Ibero-American Radiation Safety Network

A web based radiation safety network is under development to capture and analyse existing and new nuclear and radiation safety knowledge and practical experience and to disseminate it within Ibero-American countries.

The IAEA started work in late 2003, under an extrabudgetary programme on nuclear and radiation safety in Ibero-America and in close cooperation with the Forum of Ibero-American Nuclear Regulators.

Experts from Argentina, Brazil, Chile, Cuba, Mexico and Spain have been engaged in the development of the network structure. The information technology structure for the network has been developed and the network functionality requirements have been specified.

A demonstration version of the network covering four areas — application of the Code of Conduct on the Safety and Security of Radioactive Sources, the radiological protection of

patients, legal and regulatory infrastructures, and education and training — has been developed in Spain and successfully tested.

The operational concept of the network is similar to the ANSN. It includes a master index for knowledge search and retrieval of documents stored at servers located in the participating countries.

The network will facilitate on-line and off-line knowledge exchange among experts and promote a continuous and mutual learning process. It should be fully operational by the end of 2005.

#### NUCLEAR SAFETY EDUCATION AND TRAINING

The basic orientation of the IAEA's activities in this area is to support efforts in Member States to develop and to maintain up to date sustainable education and training programmes. The strategy adopted includes: the preparation of standard training materials in nuclear, radiation; transport and waste safety using the IAEA safety standards as a basis; training the trainers courses to ensure that the materials are used effectively; and, utilization of feedback to update and improve the training materials. This approach is an effective means to enhance the transfer of knowledge as compared to conventional training methods.

An essential element of the strategy is the establishment of regional and national training centres that will ultimately be responsible for delivering training courses based on IAEA curricula and training materials.

The IAEA is preparing standard training packages for areas of need identified by Member States. Standard training packages assist training centres organize courses on specific topics and help lecturers to prepare and deliver the courses. The packages contain guidance for organizing courses, viewgraphs with associated text and reference material. The challenge is to ensure and maintain the high quality of the technical and visual content of the training material.

Qualified trainers are essential for the sustainability of national education and training programmes. The IAEA provides assistance to prepare trainers both in subject and methodological matters as a means to ensure the multiplicative effect of education and training. This includes assistance to organize training courses based on IAEA's standard syllabi, preparation of exam questions, exercises and case studies for classroom discussion.

Distance learning modules are also being prepared and made available by the IAEA to Member States. A typical distance-learning package consists of a modular set of course notes, study guides and associated exercises based on specific topics from a syllabus. Participants complete the package at their place of work or at home. This method of training is an effective use of resources and permits the participants to study at their own pace. However, the success of the training depends on the self-motivation of the student to complete the work with the minimum of direct supervision. The IAEA is using this approach to ensure a common entry level of technical knowledge as a prerequisite for some of its nuclear safety courses.

A network of training centres to share experiences and training materials is an essential element of the strategy. In this context, a network is an electronic database for the exchange of training materials, as well as a forum for the exchange of information through regular meetings of training experts. To achieve a sustainable system, the concept is to have decentralized storage of documents and materials. For the Asian region, this goal is being pursued by the ANSN.

#### LOOKING AHEAD

Recognizing that nuclear safety is truly global and transboundary, the IAEA has a vision of a global safety regime that protects people and the environment from effects of ionizing radiation, minimizes the likelihood of accidents that could endanger life and property, and

effectively mitigates the effects of any such events. To achieve this vision, the IAEA will continue to attach strategic importance to the development and application of knowledge management to integrate information from diverse sources into a comprehensive and user friendly knowledge base. With the practicality and usefulness of the knowledge management techniques demonstrated, the IAEA will be steadily expanding the knowledge base to cover all important thematic and facility related knowledge. This will enhance the use of available and new safety information by the professional nuclear community and to educate and train the work force of tomorrow.

The Integrated Safety Approach, embedding effective knowledge management and networking, will allow the IAEA to proactively identify new safety trends and effectively contribute to the establishment and maintenance of a global safety regime which will best serve the needs of its Member States.

#### ACKNOWLEDGEMENTS

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