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# MANAGING SAFETY KNOWLEDGE AND SAFETY CULTURE

Capacity building required for nuclear programs has been identified by the nuclear industry, as a critical issue in ensuring nuclear safety.

There is a general consensus about that capacity building model proposed by the International Atomic Energy Agency is an adequate approach to enhance and support national nuclear policies. This model is an "umbrella process" which requires an integrated approach based on four essential elements:

- Education and training, the establishment of sustainable education and training (E&T) infrastructures and processes is fundamental to the capacity building. Education and training programmes provide a structured knowledge base for individuals involved in the utilization or control of nuclear technologies to develop their individual capacity, which by implication also means improving national capacity. During training, students and participants also develop personal networks among themselves and with the experts who provide the learning — a fundamental part of knowledge networking. E&T provides the basis for life-long human resource development.
- Human resource development, This element deals with the development of an effective workforce, by providing a structured approach to estimate the human resources needs, assess their existing capability, identify competences gaps and plan and implement activities to fill these gaps according to the nature and scope of the nuclear power programmes.
- Knowledge management (KM), an important element of effective human resource management is the management of knowledge. The knowledge that individuals need as part of the competence requirements for assigned tasks and the additional knowledge they acquire in carrying out those tasks needs to be preserved and shared widely. KM deals with capturing, structuring and transmitting this knowledge. Knowledge is the key resource of most organizations. Therefore managing knowledge effectively requires the understanding of and attention to the concept of organization knowledge rather than just traditional notion of individual knowledge.
- Knowledge Networks, Knowledge networks are established to promote the pooling, analysis and sharing of nuclear technical, safety and security knowledge and experiences at national, regional and international levels.

In this context, Nuclear Knowledge Management has become a high priority in the Nuclear Industry (organizations, power plants, workers, managers, production, operation, etc) and it has been taken into account to develop and implement specific strategies in ensuring safe and sustainable operation of nuclear facilities.

In particular, in the case of Tecnatom, one of its main roles regarding KM is to provide the system with the necessary expertise to reach its goals and objectives

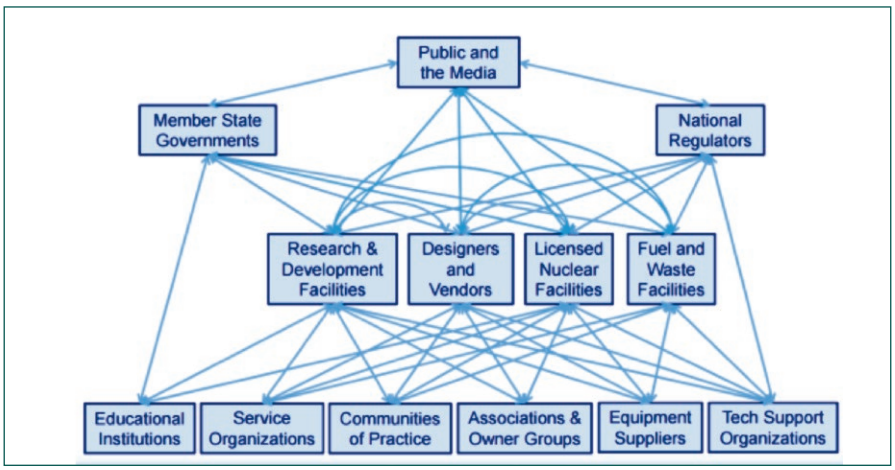


**Figure 1.** Nuclear Knowledge stakeholders Ref. IAEA.

**FRANCISCO JOSÉ RUIZ MARTÍNEZ**

Head of Training Methodology in Nuclear Training Department

TECNATOM

Education and Training Sciences Degree for the Universidad Complutense de Madrid and Máster in Human Resources Management for the EAE.

and compliance under a strict compliance with safety requirements.

Knowledge Management is defined within the IAEA as an integrated, systematic approach to identifying, acquiring, transforming, developing, disseminating, using, sharing, and preserving knowledge, relevant to achieving specified objectives.

KM consists of three fundamental components: people, processes and technology. KM focuses on people and organizational culture to stimulate the sharing and use of knowledge; on processes or methods to find, create, capture and share knowledge; and on technology to store and make knowledge accessible and to allow people to work together without being together. People are the most important component, because managing knowledge depends upon people's willingness to share and reuse knowledge (Figure 1).

Throughout the years, the technical development and Industry experience has contributed effectively to reach a notorious KM approach, which includes different processes supported by clear documentation, strategies and international cooperation.

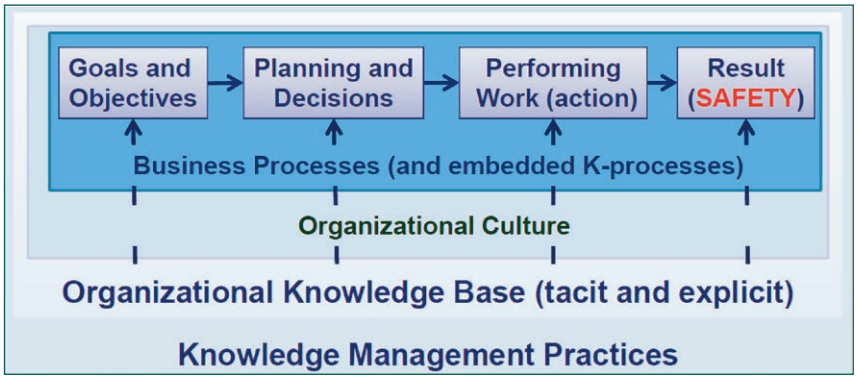


**Figure 2.** Impact of Knowledge Management Practices on Organizational Culture (working paper). Ref IAEA.

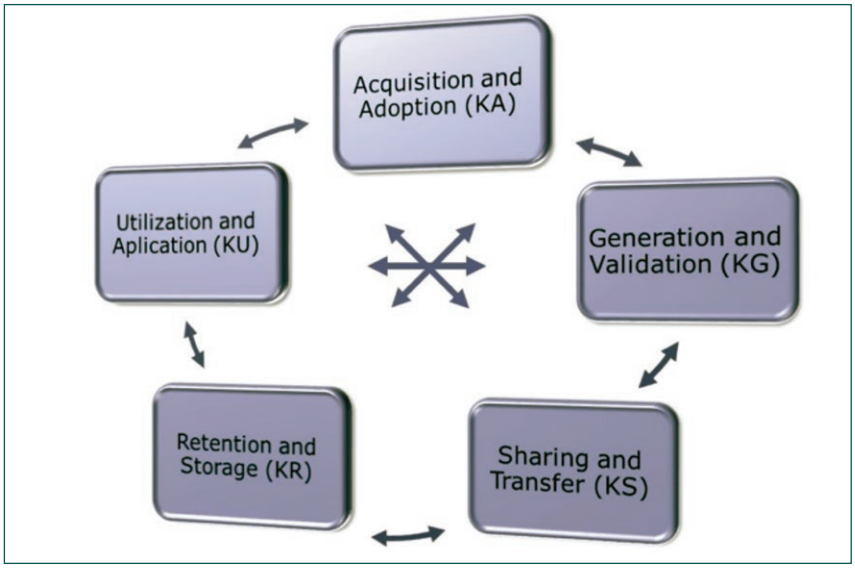


**Figure 3.** Knowledge process model

## THE IMPORTANCE OF A CULTURE OF KNOWLEDGE MANAGEMENT FOR ORGANIZATIONAL EFFECTIVENESS INCLUDING SAFETY

The results of a global KM survey conducted in 2010 by the IAEA presents interesting findings which strongly support the link between knowledge processes (that enables organizational learning) and work performance at NPPs.

In general, this survey shows that NPP organizations with higher levels of support for KM practices have higher levels of organizational effectiveness (measured across a range of performance measures that include safety, economic, operations, and maintenance indicators). And finally, the survey concludes that the extent of a supportive organizational culture has a strong positive effect on the quality of knowledge processes and organizational effectiveness. As a result of this fact, safety is enhanced in the overall organization (Figure 2).

Related to how KM impact safety, the lessons learned from the Fukushima Daiichi accident have highlighted that ensuring proper management of knowledge of all safety influences is essential to a systematic view of safety. And this systematic approach needs to consider the dynamics interactions within and among all relevant factors of the whole organizational system — individual factors (e.g. knowledge, thoughts, decisions, actions), technical factors (e.g. technology, tools, equipment) and organizational factors (e.g. management system, organizational structure, governance, resources). The accident at the Fukushima Daiichi NPP showed that it is difficult to identify vulnerabilities in systems that involve complex interactions between people, organizations and technology because basic assumption regarding nuclear safety can remain undetected .This fact implies that is necessary to understand how these three components interact in the overall system. Therefore, from a systematic view of safety, is essential a proper KM of all influences that affects safety.

## KNOWLEDGE MANAGEMENT CONTEXT

Knowledge exists in different forms and at different levels in an organization.

Tacit knowledge is experiential knowledge or 'know how' in the minds of individuals that typically cannot easily be easily expressed, captured or transferred. An example of tacit knowledge would be the know-how of an experienced maintenance engineer that allows him/her to arrive at a rapid and accurate diagnosis of problems with complex plant equipment such as a turbine.

Explicit knowledge is knowledge that has been recorded or codified in some form such as manuals, procedures, databases, or electronic media. It is important to recognize knowledge in organizations exists at an individual level, at a group level, at a department level, and at an organizational level. Further, the level of abstraction and form of knowledge

may range from detailed facts, to organized information, to interpretations and analysis, to conceptualizations, to theoretical models, or even wisdom.

There are some models that describe the mechanisms by which knowledge is accumulated, disseminated and stored in organizations and many refer to these as knowledge processes. The process model more widely used and accepted is described in Figure 3.

- Knowledge acquisition and adoption; meaning the process of obtaining and introducing new external knowledge (whether tacit or explicit) into the organization. This is interpreted to include knowledge identification and selection when for the purposes of acquisition. It also includes knowledge adoption and assimilation from sources outside the organization.
- Knowledge generation and validation; the processes for exchange of knowledge within the organization (directly or indirectly) and as also incorporating the concepts of knowledge sharing or distribution.
- Knowledge sharing and transfer; the formation or production of new knowledge and incorporates knowledge development or adaptation processes. It may also include knowledge identification and selection processes when associated with internal knowledge generation processes.
- Knowledge retention and storage; this is the process of keeping knowledge (whether tacit or explicit) within the organization and maintaining its availability. It incorporates the related concepts of knowledge capture, preservation, storage, retrieval, accessibility, identification and protection in the context of long-term knowledge sustainability.
- Knowledge utilization and application. Process that incorporates the concepts of knowledge application or use.

For example, this knowledge processes is embedded in the following nuclear plant process:

- Equipment reliability programs.
- Systematic approach to training.
- Plant Configuration management.
- Documented operational procedures.
- Plant work management systems.
- Outage planning systems.
- Pre-job briefing.
- Document management systems.


**Figure 4.** Five Phases of the SAT Process.

## TECNATOM PRACTICAL APPROACH TO SAFETY AND SAFETY CULTURE IN THE DIFFERENT PROCESSES OF KNOWLEDGE MANAGEMENT

Below is a practical approach to safety and safety culture in the different processes of KM, describing several experiences of acquisition, generation, and transfer, storage and utilization of tacit and explicit knowledge, with different stakeholders and different approaches

### Use of a Systematic Approach to Training (SAT) as an adequate methodology to organize and identify safety critical explicit knowledge

The Systematic Approach to Training (SAT) is recognized world-wide as the international best practice for establishing and maintaining the qualification and competence of nuclear power plant personnel involved in the safe and reliable nuclear power plant operation and maintenance.

SAT defines an effective, performance-based training and qualification system to accomplish the following:

- Identify what training should be provided for each position (based on analysis of job performance requirements and initial qualifications of trainees).
- Design and develop training programmes with explicit learning objectives and appropriate content.
- Conduct training as designed.
- Ensure that trainees master the learning objectives before they begin working in their assigned positions.
- Evaluate training effectiveness and use these results to maintain and improve training.

The SAT process is split into five phases: Analysis, Design, Development, Implementation and Evaluation (Figure 4).

According to Tecnatom's expertise in training programs, SAT is an adequate methodology to organize and identify safety critical explicit knowledge. This knowledge is generally found and the different procedures of the plant that rules the tasks to be performed by the plant personnel. In this sense, SAT will maintain and control a well structured and organized training system that contains the explicit cognitive and performance knowledge need by the trainee.

This knowledge is integrated in the initial and continuing programs and the overall system relies on feedback for monitoring performance and adapting to changing conditions and requirements. Each phase within the system uses feedback to identify and correct problems. This continuous feedback ensures the required standard is being met at all stages of the training process and drives continuous improvement (Figure 5).

Therefore, there are three principals outcomes derived from the application of SAT in the training programs:

- Efficiency Improvement of plant personnel as there is an initial training that comes to meet the specific needs of the different jobs positions

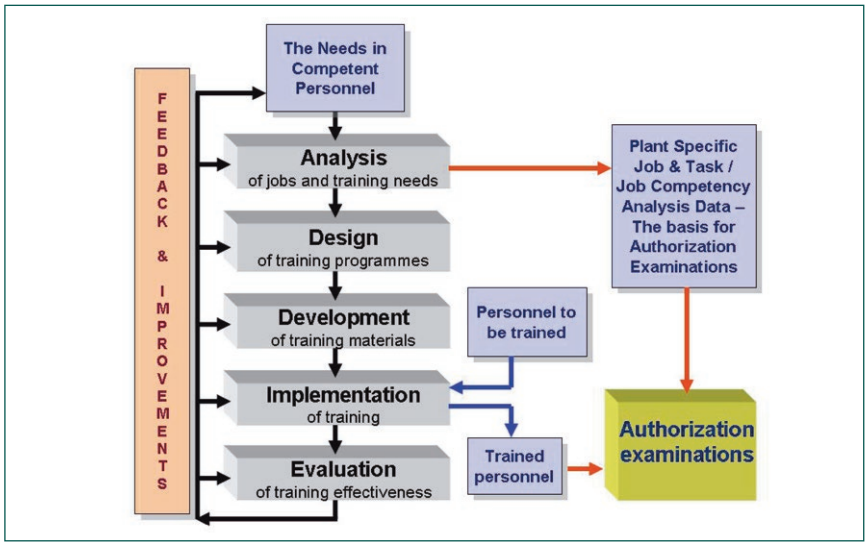


**Figure 5.** Overview of SAT methodology.

- Positive impact in the plant due to the reinforcement of manager's expectations and safe behaviours during the continuous training focused on performance improvement.
- Safety related methodology based on the identification of critical knowledge by means of a Difficulty, Importance and Frequency (DIF) Analysis.

In this way, all competency requirements for attaining and maintaining personnel competence and qualification can be met, thus promoting and strengthening quality culture and safety culture, which should be fostered throughout the initial and continuing training programmes.

**Example of Use of Knowledge Acquisition Process for Newcomers. Polish Training and Internship Programmes**

Tecnatom supports the countries called newcomers to develop the necessary competence to develop their proper nuclear training program (planning, procurement, construction, licensing, regulation, start-up and operation of a nuclear power plant).

The objective of this support is to provide those attending with an overall view of the nuclear industry and of the experiences gleaned by the Spanish industry over its more than 50 years of history.

During the last four months of 2015, Tecnatom was organizing and delivering two seminars on nuclear energy to more than 60 professionals involved in the development of the nuclear programme in the Republic of Poland.

The seminar covered all aspects of the nuclear cycle and consists of classroom sessions complemented with visits to Spanish nuclear facilities, as the fuel factory of ENUSA at Juzbado, the low and intermediate radioactive waste repository managed by ENRESA at El Cabril, the regulatory authority headquarters or the Ascó nuclear power plant. Topics such as simulation methods, nuclear safety, security procedures, radiological protection, efficiency in generation, social perceptions of nuclear energy and good practices in industry interrelations were among the disciplines delivered during this seminar. The main nuclear vendors: Westinghouse, General Electric and AREVA were also involved in the seminar.

**Knowledge Generation by means of transference and dissemination of Operating Experience and Lessons Learned – Safety Moments.**

A safety moment is a brief discussion on a safety-related topic that occurs at the beginning of a meeting, workshop, job or training activity. Safety moments are designed to remind employees about safe practices, lessons learned habits and issues related to safety and cover topics such as error prevention tools, events that jeopardize nuclear safety, lift of heavy loads.

Safety moments are efficient tools to contribute to a corporate safety culture that values and reinforce safe practices.

Through safety moment, lessons learned extracted of events generate safety awareness in the organization. This knowledge is increases in this talk is led by managers or supervisors, setting-up a top-down approach that, for example, encourages front line workers to report on unsafe conditions and hazards in their area or apply error prevention tools previously well aware but not usually implemented (Figure 6).

**Cooperation between China and Europe to improve the capabilities of China in the field of Nuclear Safety in the areas of emergency management and the management of severe accidents**

Cross-border Cooperation projects are means of knowledge sharing between organizations that have a sound foundation in nuclear subjects and countries that wants to improve their safety competences.

In this sense, Tecnatom participates in the European Commission, under the auspices of the Instrument for Nuclear Safety Cooperation (INSC), supports of the People's Republic of China in the prevention and management of severe accidents and arrangements for emergency preparedness and response in the field of nuclear safety.

The overall objective of this cooperation between EU and Chinese authorities is to improve the capabilities of key Chinese organizations to best international standards and practices by transferring European knowledge and experience in the field of nuclear safety and more specifically in the areas of Preparedness and management of radiological and nuclear emergency and Analysis and management of severe accidents.

It aims, on the one hand, to share the current standards and arrangements for radiological and nuclear emergency management in China in the light of European and international experience in order to develop timely and effective airborne monitoring.

On the other hand, the project targets the enhancement of the capabilities of the Chinese Nuclear Power Technology Research Institute in particular in the areas of severe accident management guidelines (SAMG) for plant shutdown conditions and damaged fuel in spent fuel storage ponds and of interfaces between SAMG and emer-

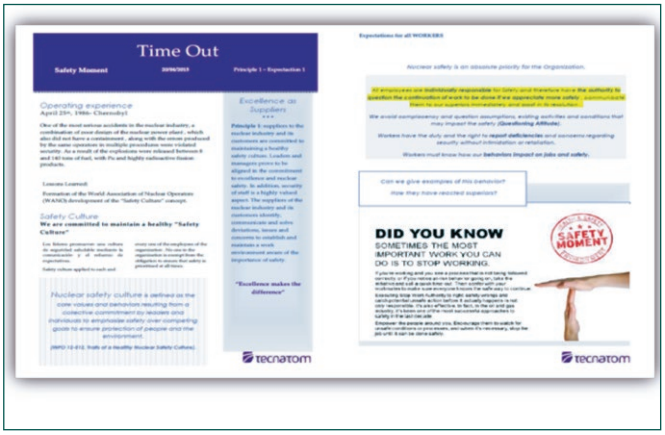


**Figure 6.** Example of a Safety Moment used in the Tecnatom Meetings.


**Figure 7.** Participants of the EU-China cooperation program in the field of Nuclear Safety.

gency operating procedures and on- and off-site emergency preparedness.

The project is based on the expertise of Tecnatom and other three experienced European companies (IRE/IRE ELiT, SCK-CEN and UJV Rez)

Knowledge sharing instruments include "On-the-Job" training of Chinese experts in the EU organizations and specific workshops in China

At the end of the project, as a final dissemination process the outcomes of this project will be widely disseminated and serve as direct inputs for future planned activities of the European, International and Chinese organizations within the field of nuclear safety (Figure 7).

## Use of advanced training environments with the use of dynamic and task simulators as a Knowledge transfer process

The dynamics simulators are training tools for performance improvement focused on people working with high performance requirements that have to acquire knowledge, skills and attitudes with a triple target: technical knowledge, skills oriented to task and safety culture. Dynamic simulator permits to replicate real plant conditions in a controlled and safe environment where the worker performance will be observed and improved according with standards and plant expectations.


**Figure 8.** Training station.

**Figure 9.** Hydraulic Loop.

Tecnatom use the dynamic simulators during the training with the objective of enhancing safety culture and nuclear professionalism of trainees. For this purpose training stations sessions are developed based in operating experience mainly oriented to implement behaviour expectation for generic subjects like housekeeping, labelling, radiological protection and industrial safety issues. Workers during their training will respond to different scenarios according with plant expectations (Figure 8).

Training stations are part of the called "Human Factor Simulator or Field Simulators" and are channels of knowledge transference from the plant expectations and good practices of the plant and its acquisitions by the workers.

Example of knowledge that is transferred in training stations: Emergency plan / Fire protection, Personal protective equipment, Chemical products, Foreign material exclusion, Lifting and rigging, Working at height, Confined space works, Electrical safety, Radiological protection, Equipment tag out and clearance and Human error prevention techniques (Figure 9).

Dynamic simulators also include a Hydraulic loop, in which the working team will have to perform a real task (scenario) in a controlled environment that simulates the plant atmosphere. Training, in this case, is focused in the transfer of professional behaviours according with work management processes, plant expectations and work procedures. Scenarios include the participation of line supervisors who plays a key role in reinforcing safe behaviour, coaching or correction worker performance. The incorporation of supervisors in the training improve knowledge sharing, by the fact that he will monitor the training activities and incorporate lessons learned from their work operating experience.

**Figure 10.** Scene from a 360° point of view recording.

### Use of action cameras and 360 videos during the implementation of On-the-Job (OJT) training as a Knowledge Application process

One of virtual reality applications is the development of new learning environments. Tecnatom is developing a 360° virtual reality simulator that allows the training of the most representative tasks performed by different groups (Operations, Maintenance, Engineering, Radiation Protection, etc.) working in a nuclear power plant by means of the display on virtual reality glasses, mobiles, tablets, etc (Figure 10).

The Tecnatom's 360° virtual reality simulator allows the immersion in the work environment, permits access to restricted areas and thus, reducing the doses received by the trainee.

Regarding KM, is a share method in which "subject matter experts" are recorded meanwhile performing a task, and all this expertise can be shared with the trainees or in Just-In-Time training. The inclusion in a web platform will give us the possibility of using the tool anywhere and anytime and in different collectives during their initial or continuing training.

### Nushare Project as an example of Knowledge Management for Sharing & Growing Nuclear Safety Culture Competence

Nushare project is originated by the need to develop and implement education, training and information (ETI) programmes aimed at strengthening safety culture in the nuclear sector and at sharing relevant best practices at the European level.

The project addressed safety culture in all types of nuclear activities including security applications. But, it is focused on competences relevant for ensuring safety culture in the operation and the regulation of nuclear installations. Also, particular attention is paid to lessons learned from stress tests conducted on all EU nuclear Power Plants in response to the Fukushima accident and to sharing best practices at the European level

NUSHARE addresses the specific needs of different stakeholders in nuclear safety by the development and EU-wide dissemination of programmes for three target group ((1) Policy decision makers and opinion leaders, (2) Nuclear Regulatory Authorities and Technical Safety Organisations, (3) and Electric utilities and Suppliers) and its impact in the nuclear industry is:

- Further strengthening of nuclear safety and security, including emergency preparedness and crisis communication.
- Europe-wide dissemination of best practices suitable to achieve excellence in nuclear safety culture.
- Expanding the basic understanding of these and related topics beyond the nuclear community.

Tecnatom has participated in this project with other partners (CEA/INSTN, ENSTTI, UPM, ENEN, ISAR and AREVA).

NUSHARE project has include the development of a "NUSAHRE catalogue" that includes the existing ETI programmes deemed suitable to effectively support excellence in safety culture in nuclear activities at a European level and the design, development and implementation of the ETI programmes for each of the three target groups.

Under this project several programs have been developed. One of those is the "Program on Culture for Safety", developed by Tecnatom and focused in supporting Tops Level Managers of the Nuclear Industry in their work to improve Culture for safety in Europe. This program takes into account the needs and availability of the managers and is designed as a blended learning which includes a short webinar, 11 micro mobile-e-learnings and a workshop of one day. Also includes a Forum to share experiences in the implementation of actions (Figure 11).

### FINAL CONCLUSIONS

The conclusions derived from these practical approaches of Knowledge Management process in the Tecnatom training activities are the following:

- It is important a systemic view of safety and therefore the KM of the different aspects that contribute to safety.
- Culture is an enabler of KM.
- There is a lot of Explicit Knowledge that is necessary to organize and emphasize its importance for safety.
- Also there is a lot of Tacit Knowledge that is necessary to capture, store and share.
- It is important to take advantage of different settings, technologies and tools to be efficient in safety KM.
- KM is dependent of the target group.■


**Figure 11.** "Program on Culture for Safety" Micro mobile e-learnings.