IAEA-TECDOC-1675

# *Knowledge Management for Nuclear Research and Development Organizations*

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International Atomic Energy Agency

# Knowledge Management for Nuclear Research and Development Organizations

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# KNOWLEDGE MANAGEMENT FOR NUCLEAR RESEARCH AND DEVELOPMENT ORGANIZATIONS

INTERNATIONAL ATOMIC ENERGY AGENCY
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## FOREWORD

The use of nuclear technology relies on the creation, storage and dissemination of knowledge. Nuclear knowledge management in a research and development context therefore has an important place in nurturing innovation and facilitating future development of nuclear technologies for nuclear power, its associated fuel cycles and nuclear applications in medicine, industry and agriculture.

The IAEA nuclear knowledge management activities assist in transferring and preserving knowledge, exchanging information, establishing and supporting cooperative networks, and training the next generation of nuclear experts. These activities in assisting Member States in the preservation and enhancement of nuclear knowledge and in facilitating international collaboration have been recognized by the General Conference of the International Atomic Energy Agency in resolutions GC(46)/RES/11B, GC(47)/RES/10B, GC(48)/RES/13, GC(50)/RES/13, GC(52)/12 and GC(54)/10.

Much work has been done by the IAEA in addressing the knowledge management needs of different nuclear organizations, resulting in the following publications:

— Knowledge Management for Nuclear Industry Operating Organizations, IAEA-TECDOC-1510;
— Development of Knowledge Portals for Nuclear Power Plants, IAEA Nuclear Energy Series No. NG-T-6.2;
— Risk Management of Knowledge Loss in Nuclear Industry Organizations;
— Planning and Execution of Knowledge Management Assist Missions for Nuclear Organizations, IAEA-TECDOC-1586.

This publication has been developed to address the specific needs of nuclear research and development and technical support organizations, which have unique features that are not captured in the above guidance publications. Its purpose is to provide assistance to decision makers from nuclear research and development organizations on planning, implementing and sustaining knowledge management programmes to derive business benefit.

Appreciation is expressed to all participants who contributed to the production of this report. Particular thanks are due to G. Cairns from the UK for his assistance in the initial preparation of this report. The IAEA officers responsible for this report were A. Kosilov, M. Sbaffoni and Y. Yanev of the Department of Nuclear Energy.

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# 1. INTRODUCTION

There are five main characteristics that have to be considered when managing nuclear knowledge:

- Complexity — nuclear knowledge is highly complex on both the micro and macro-scale. The physical, chemical, radiological and biological interactions of materials as well as the sociological, economic, political and security aspects must all be considered as a whole.
- Cost — largely due to its complexity, the creation of nuclear knowledge is quite costly. Nuclear facility construction and operation are often large, complex engineering projects requiring sophisticated safety systems and specialist staff.
- Timescale — the time period between the creation of knowledge and its use can be very long. For example, the time between radioactive waste being created and its disposal could be many decades. During this time, the information, the capability to access, interpret and understand it, must to be maintained.
- Cooperation — many individuals, organizations and Member States have legitimate cause for both contributing to and accessing the nuclear knowledge base. The information and data used and the experiences, skills and insights applied must be carefully monitored to guarantee robustness.
- Education — is essential if people are to acquire the experiences and insights needed to create new knowledge and apply it to emerging challenges.

The industrial infrastructure required to create and maintain the full scope of nuclear knowledge can represent a significant economic and technical burden for many Member States. This infrastructure includes research and development (R&D) and technical support organizations, laboratories to handle a wide variety of nuclear materials, research and power reactors, hot cells, reprocessing plants, demonstration facilities and disposal sites. These have to be supported by skilled operators, health physicists, regulatory and licensing bodies, quality and financial controllers. In recent years, the cost of maintaining such an infrastructure has risen. Willingness to share nuclear knowledge means more Member States, particularly in developing regions, are likely to have access to life-changing technology without the crippling burden of infrastructure costs.

Effective management of nuclear facilities requires suitably qualified personnel. An important element of 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. This knowledge will be needed by several generations of the workforce during the lifetime of the nuclear energy programme. As the nuclear workforce ages and retires, the number of suitably qualified and experienced staff will decline and the knowledge they possess may be lost. Action is being taken to address this with the development of higher education programmes that focus, specifically, on nuclear technology and its application. However, many of these programmes are still in their infancy, and rely on concerted government and academic support — and both bodies are under constant pressure to demonstrate that they make best use of public funding. In some case it could take decades of support before the benefits are realised and, in the meantime, nuclear safety and security may be at risk. Furthermore, innovation will be compromised. Specialist knowledge is needed to apply nuclear technology in medicine, agriculture, industry, disease prevention, water management, electricity production and mineral exploration. If the knowledge accumulated to date is lost, applications will stall and many generations could have a less secure and sustainable future. These factors have led to the need for effective strategies and policies for knowledge management (KM) [1].

During the initial stages of implementing a KM programme, the IAEA focused its attention primarily on the implementation of nuclear knowledge management (NKM) at operating nuclear power plants (NPP). As awareness of the value of the NKM methods and tools became more widespread, the IAEA received additional requests to consider a broader application in other types of nuclear operating organization. One such area identified for attention was the specific application in nuclear R&D organizations. This publication is written to support this aim.

## 2. PURPOSE

The purpose of the publication is to provide assistance to decision makers from nuclear R&D organizations on planning, implementing and sustaining knowledge management programmes to derive organizational benefit. It uses existing IAEA nuclear KM concepts and publicationation and extends the applicability to a range of activities currently undertaken by nuclear R&D organizations.

## 3. SCOPE

The scope of this publication is intended to cover a range of activities undertaken in different types of nuclear R&D organization as defined in Section 4. It considers many aspects of KM and has specific guidance relevant to the following topic areas:

— Measuring KM maturity in R&D organizations;
— Identification of critical knowledge;
— Collaboration strategies;
— Explicit and tacit knowledge capture;
— IT tools and techniques;
— Links with the quality management system;
— Guidelines for successful implementation;
— IAEA guidance and assistance in the establishment and maturity assessment of an NKM programme.

It is not within the scope of this publication to cover every aspect of KM (particularly all possible methods, tools and techniques) or to repeat information that can be found in existing IAEA publications on the subject. As appropriate, references to such documentation will be made throughout the various sections of the publication in the context of applicability to nuclear R&D organizations.

## 4. ORGANIZATIONAL CONTEXT

There are many different types of nuclear R&D organization operating worldwide. Some are financed by government and others operate on a self-funded basis or are privately owned. For the purposes of this publication, the IAEA have identified the following seven different types of activities/functions undertaken by R&D organizations:

(a) Basic research functions:
Basic research or fundamental research (sometimes called pure research) is research carried out to increase understanding of fundamental principles. In many cases the end results have no direct or immediate commercial benefits. Basic research can be thought of as arising out of curiosity. In nuclear R&D organizations such research may include research into the properties of radioactive materials e.g. isotope analysis, transmutation, radioactive decay, neutron absorption/scattering etc. It may also include research into non-radioactive materials and related areas of science such as corrosion, fluid flow, heat transfer and acoustics etc. The output of such research is invariably a

technical paper that supports a new theory or validates exiting concepts and models.

(b) Applied research functions:
Applied research is research accessing and using existing theories, knowledge, methods and techniques for a specific government, commercial or client driven purpose. In nuclear R&D organizations such research is often required to support nuclear safety cases or efficient operation of nuclear facilities. As with basic research, applied research may involve both radioactive and non-radioactive materials and can include a range of scientific disciplines. The output from an applied research organization is a technical solution, design or product that may or may not be supported by a technical paper or report.

(c) Design R&D functions:
In the context of this report, design R&D is concerned with undertaking research and development activities which directly supports the design of nuclear facilities or equipment. It includes radioactive and non-radioactive materials research and development. In simple terms, design R&D organizations can be considered to be a special sub-set of applied research organizations as defined above.

(d) Functions utilizing nuclear R&D facilities:
This typically represents the situation where a nuclear R&D organization runs a research reactor or similar facility utilizing ionizing radiation. In addition to research reactors, experimental equipment may include devices such as particle accelerators, X ray machines and devices requiring radiation sources. This type of organization is usually characterized by the need for external regulation and the presence of an on-site radiation protection advisor (RPA). The purpose of such an organization can be to deliver pure or applied research as described above.

(e) Functions utilizing non-nuclear R&D facilities:
This case represents a nuclear R&D organization that operates equipment used for research and development that does not utilize ionizing radiation. This may include apparatus needed for metallurgy, heat transfer, and chemistry experiments etc. that are required to support nuclear applications or facilities. Again, as with nuclear R&D facilities, the purpose of such an organization can be to deliver both pure and applied research.

(f) Educational R&D functions:
Educational R&D organizations represent a special type of organization with the principal role of educating students and other learners in nuclear technology. Such organizations typically utilize research reactors and other nuclear equipment as described above to facilitate the learning process. Both pure and applied research projects are often used to support learning.

(g) Technical support and services functions:
These organizations directly support client organizations that operate nuclear facilities. This support may take many forms, including any of the R&D functions described above.

In practice most R&D organizations operate in a number of different modes offering capabilities covering all or most of the functions described above. This is important from a KM point of view as the business issues facing R&D organizations are often different depending on the organizational function and structure.

## 5. HOW KNOWLEDGE MANAGEMENT CAN BENEFIT NUCLEAR R&D ORGANIZATIONS

It is important to understand what KM is and how it can help R&D organizations. Definitions and practical examples of the application of KM can be found in several IAEA publications:

— Knowledge Management for Nuclear Industry Operating Organizations, IAEA-TECDOC-1510 (see Ref. [1]);
— Risk Management of Knowledge Loss in Nuclear Industry Organizations [2];
— Managing Nuclear Knowledge [3];
— Managing Nuclear Knowledge: Strategies and Human Resource Development [4];
— Planning and Execution of Knowledge Management Assist Missions for Nuclear Organizations, IAEA-TECDOC-1586 [5];
— Comparative Analysis of Methods and Tools for Knowledge Preservation [6];
— Status and Trends in Nuclear Education [7].

Although the above references are mainly aimed towards KM in nuclear power plants, there are a number of related areas that are applicable to nuclear R&D organizations. It should be recognized, however, that nuclear R&D organizations also have some special features and issues that require a different KM approach. A description of some of these issues, particularly relevant to nuclear R&D organizations and the benefits that can be realized is given in paras 5.1–5.8. Each section considers the type of R&D organization that is applicable and the KM tools and techniques that should be considered for application/improvement.

## 5.1. MITIGATING SINGLETON RELIANCE

Nuclear R&D organizations rely to a great extent on competent personnel who are specialists in their field. A high proportion of staff are regarded as technical experts, and many have no back-up or immediate successor, i.e. they are regarded as 'singletons'. This is a significant issue for all types of nuclear R&D organization. The situation is often exacerbated by ageing staff, lack of funding and cost cutting strategies which often puts pressure on the recruitment and handover processes. Although succession planning processes do exist in a number of R&D organizations, a widespread adoption of KM techniques that can be deployed to address the singleton issue are not widely observed. This is a key area where KM can provide benefit.

(a) Applicable organizational functions:
All types of R&D organization.
(b) Related KM tools/techniques to consider:
  — Identification of critical knowledge;
  — Knowledge loss risk assessment;
  — Succession planning;
  — Tacit knowledge capture;
  — Explicit knowledge search/find;
  — IT tools to facilitate the techniques above.

## 5.2. IMPROVING INNOVATION

The ability to innovate is a common element associated with all types of R&D organization and sets R&D organizations apart from other nuclear organizations such as operating NPPs.

Innovation can be regarded as comprising three main components: new-use of existing knowledge, creation of new ideas, and exploitation of those ideas to create value for the organization. Innovation requires a holistic approach to problem solving and the ability to link separate concepts together to produce a new result. The process can be carried out by individuals but faster, better results are usually achieved by teamwork and group collaboration. Social interaction is therefore a key success factor for innovation and KM tools and techniques can play an important role in improving innovation potential.

(a) Applicable organizational functions:
All types of R&D organization.

(b) Related KM tools/techniques to consider:
   - Communities of practice (CoP);
   - Knowledge base systems;
   - Explicit knowledge search/find;
   - Collaboration and social networking tools;
   - Rapid evidence reviews;
   - Peer assist;
   - Knowledge café.

## 5.3. DEVELOPING COLLABORATION RELATIONSHIPS AND PARTNERSHIPS

Nuclear R&D organizations are becoming increasingly involved in the development of international strategic alliances that require the sharing of research staff and their knowledge in international networks of excellence. This aspect applies to all types of R&D organization and is more prevalent in those organizations that are state or publicly funded. Such collaboration and partnership between R&D institutes, government, universities and industry require a flexible approach and this process can be facilitated by the introduction of various KM tools and techniques as described in Section 6. The overall benefits of this approach can be realized in terms of efficiency (cost) savings and reputation in adopting new and innovative solutions as described in para 5.2.

(a) Applicable organizational functions:
    All types of R&D organization.

(b) Related KM tools/techniques to consider:
   - Communities of practice;
   - Collaboration and social networking tools;
   - Rapid evidence reviews;
   - Peer assist;
   - Knowledge café;
   - Knowledge marketplace.

## 5.4. MAKING THE BEST USE OF AVAILABLE FUNDS

Most R&D organizations have experienced cutbacks in funding or have been required to make reductions in expenditure. Adoption of good KM practices is unlikely to lead to increased funding options from sponsors but can lead to increased efficiency and possible cost savings. This ensures that all funding is correctly assigned and the maximum benefit is derived with the limited funds available. To realize these savings it is necessary to fully understand the benefits that KM tools and techniques can bring and to run KM projects with this end goal in mind. More information on identifying viable KM projects and the processes for successful implementation can be found in Section 7.

(a) Applicable organizational functions:
    All types of R&D organization.

(b) Related KM tools/techniques to consider:
    All — but with a targeted approach to address areas of inefficiency.

## 5.5. MAINTAINING AND DEVELOPING STAFF COMPETENCE

Utilizing explicit and tacit knowledge is an essential ingredient for a nuclear R&D organization, but employing staff with the correct level of competence is likely to be a more important success factor. Laboratory managers, subject matter experts (SME) and senior laboratory technicians for example, may have lots of knowledge but is it the right knowledge?

In addition do they have the correct attitudes and skills? Maintaining and developing staff competence is a very important aspect in any nuclear R&D organization. There are some useful tools and techniques that can be utilized to maintain and develop competence. The most important of these are given in the list below and these augment the various types of standard education and training which is the typical route to maintain and develop competence.

(a) Applicable organizational functions:
All types of R&D organization.
(b) Related KM tools/techniques to consider:
- Competency frameworks;
- Skills/competency management database tools;
- Identification of critical knowledge;
- Knowledge loss risk assessment;
- Succession planning;
- Communities of practice;
- Collaboration and social networking tools;
- Rapid evidence reviews;
- Peer assist;
- Knowledge café;
- Knowledge marketplace.

## 5.6. PROTECTING INTELLECTUAL PROPERTY

Intellectual property (IP) is an intangible asset that has commercial value. In nuclear R&D organizations the development of IP is a key deliverable of the organization and as such should be protected. As well as physical assets such as designs, inventions, software etc. 'employee know-how' is also regarded as IP. In fact the value of employee know-how in many R&D organizations far outweighs the value of physical assets. Protecting all kinds of IP involves:
- Taking an inventory of existing IP;
- Assessing IP value;
- Implementing controls on high value items and then integrating these controls into the management system.

Taking an inventory of 'employee know-how' is essentially the same task as identifying critical knowledge in the organization, hence there is an obvious linkage here with the KM tools and techniques described in Section 6 of this publication.

(a) Applicable organizational functions;
All types of R&D organization, but with particular relevance to:
- Applied research functions;
- Design R&D functions;
- Technical support & services functions.
(b) Related KM tools/techniques to consider:
- Identification of critical knowledge;
- Knowledge loss risk assessment;
- Succession planning;
- Tacit knowledge capture;
- Explicit knowledge search/find;
- IT tools to facilitate the techniques above.

### 5.7. DELIVERY OF NUCLEAR EDUCATION

Delivery of nuclear education is important in R&D organizations whose principal function involves teaching and the supply of qualified students to the nuclear industry where recent trends indicate a growing demand. Successful delivery of educational and training programmes requires a transfer of knowledge (see Ref. [6]). A multi-strand approach is needed and the tools used to facilitate education and training closely align with the tools used for successful KM delivery. This relationship is becoming more apparent given recent developments to deliver nuclear training courses 'on-line' in a virtual classroom environment. The IAEA itself is involved in this process and has contributed through programmes such as the World Nuclear University (WNU) and Asian Network for Education in Nuclear Technology (ANENT). A number of techniques used in KM are relevant here and are provided in the flowing list.

(a) Applicable organizational functions:
Educational R&D organizations.
(b) Related KM tools/techniques to consider:
- — Explicit knowledge search/find;
- — IT tools such as portals and collaboration tools.

### 5.8. COMPLIANCE WITH NUCLEAR LEGISLATIVE REQUIREMENTS

R&D organizations operating research reactors and related facilties need to comply with nuclear legislative requirements similar to those applicable to NPPs. The detailed legislative requirements vary from countrty to country but there are some common aspects that must be addressed. These aspects are related to KM and include:
- — Mainitaining/demonstrating competency of staff;
- — Provision of education and training;
- — Organizational design and management of change considerations;
- — Document and record management.

(a) Applicable organizational functions — organizations utilizing nuclear R&D facilities;
(b) Related KM tools/techniques to consider:
- — Competency frameworks;
- — Skills/competency management database tools;
- — Identification of critical knowledge;
- — Knowledge loss risk assessment;
- — Succession planning;
- — Explicit knowledge search/find;
- — IT tools such as document/content management systems, portals and collaboration tools.

## 6. KM TOOLS AND TECHNIQUES FOR R&D ORGANIZATIONS

The purpose of this section is to provide a brief outline of the KM tools and techniques that nuclear R&D organizations should consider to help deliver business benefit to the organization. This is not an exhaustive list, nor is it possible in this section to provide a comprehensive guide on applicability and usage. Where information exists within other IAEA publications this is referenced as appropriate. In addition, a set of definitions of NKM terminology is included in the Annex to the publication.

## 6.1. KM ANALYSIS TOOLS

### 6.1.1. KM maturity self-assessment

Self-assessments are used to help determine the current KM capability in an organization and to assist in identifying KM areas for future improvement. The IAEA has produced a self-assessment questionnaire and Excel spreadsheet specifically for nuclear R&D organizations that can be used to facilitate the process. This is currently not available in existing IAEA publications but a copy of the self-assessment questionnaire is available in Appendix of this publication.

The self-assessment questionnaire is best used in a group or workshop environment and can be completed by collecting responses from a number of people who are knowledgeable with regards to the organization's activities and future goals.

### 6.1.2. Knowledge loss risk assessment

Knowledge loss risk assessment is the process used to determine the potential business impact of the loss of critical knowledge from an organization. The process for attrition based risk assessment is described in Ref. [3]. The process uses a risk assessment matrix, which focuses on two key parameters:

- Position risk (i.e. based on the unique/critical knowledge and skills possessed by the employee and an estimate of the difficulty or level of effort required to refill the position);
- Attrition risk (i.e. based on the expected retirement or other attrition date of an employee).

Based on the combination of the two above factors, a total knowledge loss risk factor can be derived for each individual in the organization.

A knowledge loss risk assessment is a useful starting point for establishing the priorities by which key individuals in an organization can be targeted for knowledge elicitation/harvesting or other mitigation actions. Currently the IAEA documentation considers only knowledge loss due to attrition (staff that leaves due to retirement, transfer or termination) but the methodology is readily extended to address other situations.

### 6.1.3. Identification of critical knowledge

Identification of critical knowledge is an exercise that every organization should carry out to help identify those individuals who are critical to its continued success. Generally it is carried out as part of a knowledge loss risk assessment as described in para 6.1.2. The process in the IAEA is well documented and has been used or demonstrated at a number of NPPs worldwide. The reference [3] describes the process, gives guidance for mangers and describes the interview process to confirm that an individual's knowledge is indeed critical to the organization's activities.

### 6.1.4. Rapid evidence review

A rapid evidence review (RER) provides R&D organizations with a way of quickly reviewing research and development evidence on a particular subject and consolidating knowledge at the beginning of a new project or study. It is a collaborative approach that looks at what has already been done in a particular research domain and captures the main issues, results, methods and outcomes. The RER provides a quick and useful way of gathering and consolidating knowledge and is a useful building block from which to start work on a new project. It should not be considered a definitive review, but rather the most suitable given the time and resources available.

Any new piece of work is likely to draw on what has already been done by others in the domain. An RER ensures that an organization can take account of this work before starting a project, thus avoiding duplication of effort, giving a firm foundation on which to build the project or activity.

In practice, an RER can be executed and completed in a number of different ways. A fully-developed review will search available literature as comprehensively as possible, using electronic databases, the internet and other information sources such as books, research papers, and training courses etc., both inside and outside the organization. Group techniques are also used with experts to gather information on the topic of interest. The output from an RER is usually a report or document that summarises the main findings and outcomes from the desk based research and discussions with the experts.

## 6.2. KNOWLEDGE CAPTURE TECHNIQUES

R&D organizations have many experts who have tacit knowledge and this is usually the most important resource of the organization and a resource that it very difficult to measure. Many of the benefits described in Section 5 of this publication are realized through the capture, dissemination and re-use of this knowledge. The techniques used to extract tacit knowledge are therefore of key significance to R&D organizations and are described in the sections that follow.

### 6.2.1. Interview techniques

Interviews are important in helping to understand and capture knowledge associated with an expert's role. Interviews are not the best method of capturing tacit knowledge or validating knowledge but they provide an important starting point to allow other techniques to be used later. There are three main types of interview technique:

- Unstructured interviews have an outline agenda but no pre-defined questions or structure;
- Semi-structured interviews (the most commonly used) have a structured agenda with the flexibility to ask additional questions following an answer;
- Structured interviews; these allow no flexibility; all questions are established in advance.

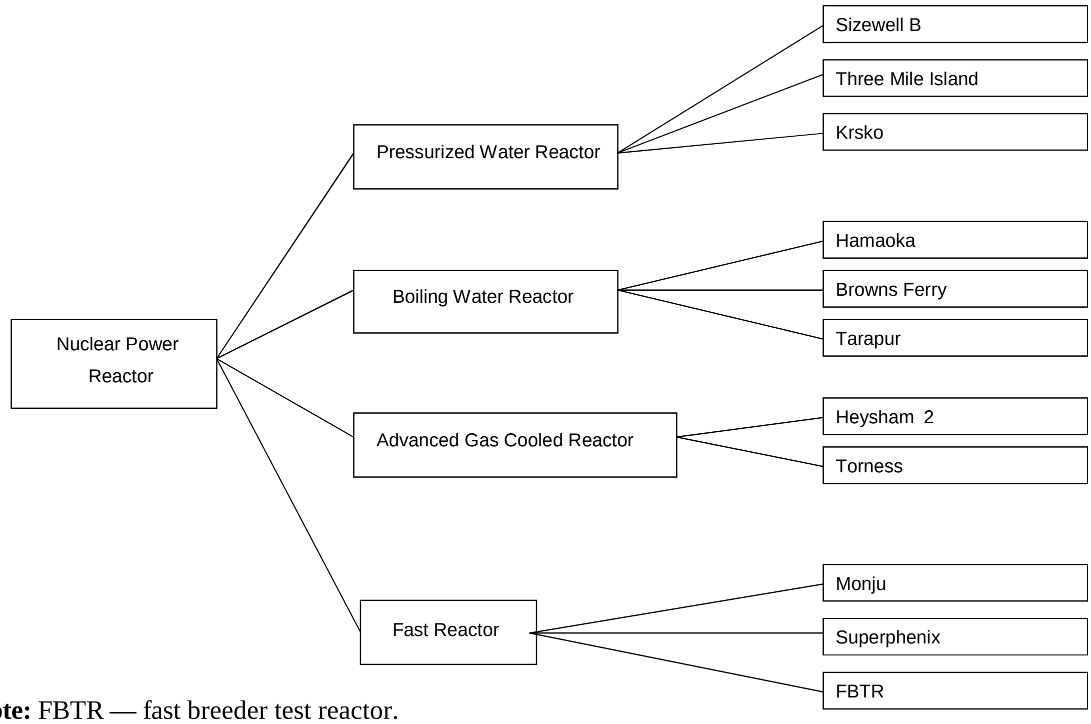
Interviews can be combined with workshops to establish need, purpose and commitment from a group of experts. Interviews are usually recorded. Audio recording is the usual method, which is then converted into a document transcript. The duration of interviews can be long (in total these can extend to several man-days duration) depending on the subject matter expert under review and the extent of knowledge to be captured.

The interview requires a considerable amount of pre-planning and works well when a bespoke set of questions are pre-determined. Basic interviews can be combined with other specialist interview techniques such as the critical decision method (CDM), popular with the US military, which focuses on non-routine incidents and the decision making processes of the experts at the

### 6.2.2. Laddering and concept mapping

Laddering and concept mapping are diagrammatic ways of representing knowledge in a particular area or 'knowledge domain'. Laddering uses a hierarchical approach to show relationships between concepts (see Fig. 1).

A concept map is similar to a ladder. However, the layout usually starts from a central theme and shows concepts as nodes and the relationships between them as labelled arrows (see Fig. 2).




**Note:** FBTR — fast breeder test reactor.

*FIG. 1. Example concept ladder or tree.*

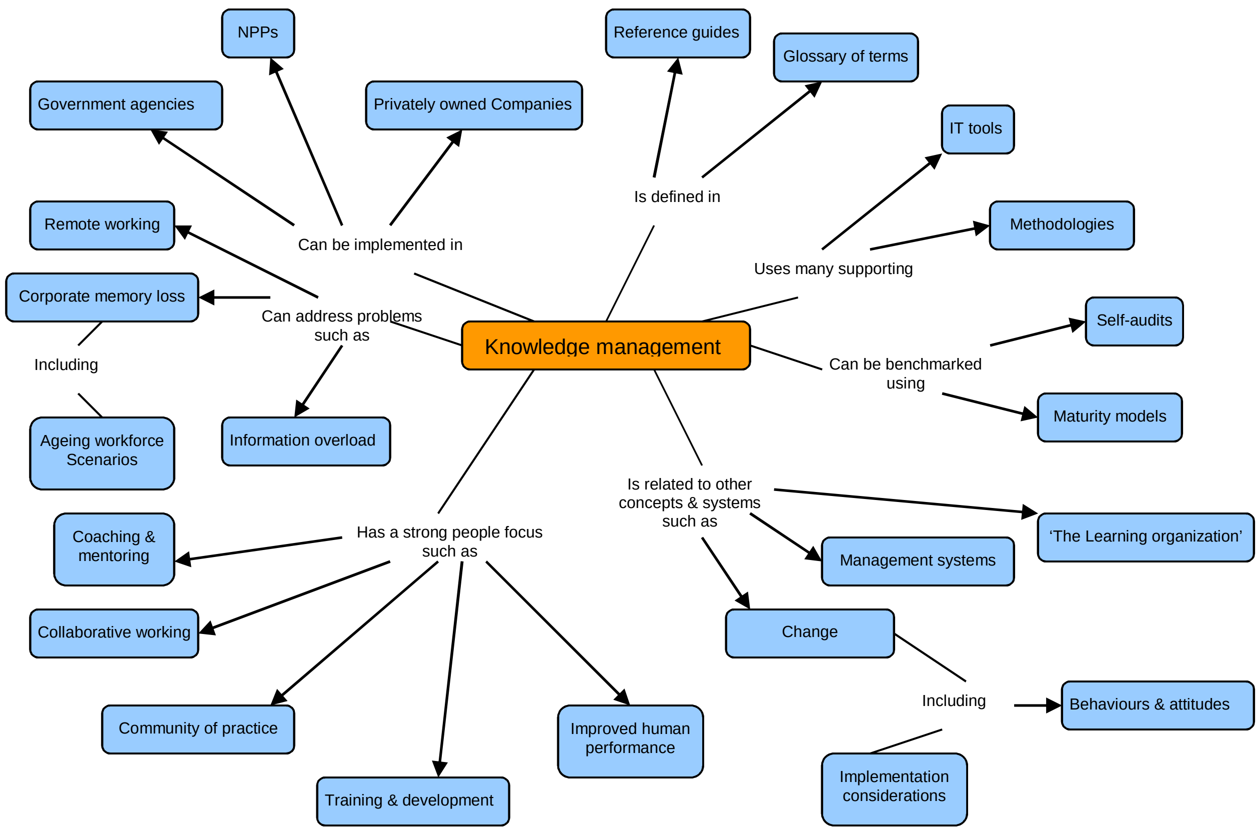



*FIG. 2. Example of concept map.*

Addering and concept mapping techniques can be used with interview techniques to model knowledge. Alternatively experts can contribute directly to the production of the models. In this way, ladders and concept maps provide a better way of identifying and capturing tacit knowledge rather than interviews alone.

### 6.2.3. Process mapping

Processes are characterized by stages, actions or events, with each stage having inputs and outputs. Much tacit knowledge in the heads of experts is process knowledge and this is often gained from many years of experience working in an R&D environment. An example of process knowledge in an R&D context includes knowledge related to:

— Establishing and prioritizing the need for research;
— Methodologies in designing and operating experiments or tests;
— Specialist calibration activities;
— Logical deduction, such as root cause analysis.

Process knowledge is often found in narrative procedures but is usually better represented and understood by the construction of process maps or models. These can take many forms and are often found in support of business processes (see Fig. 3).

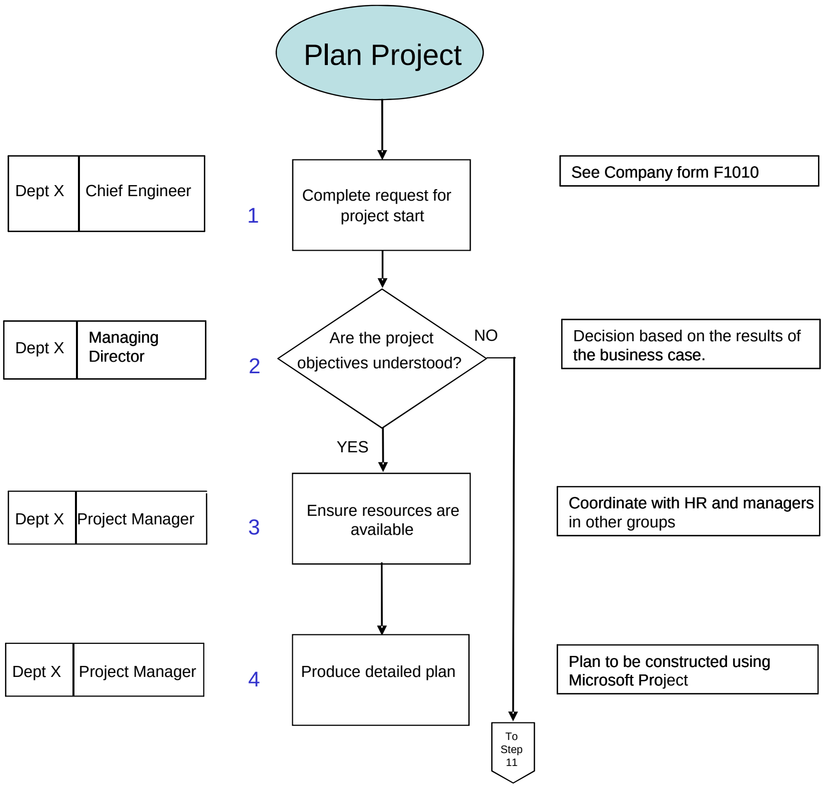



*FIG. 3. Process map.*

Process maps can be constructed directly with experts to help model process knowledge. As with concept maps, the input for process models can be generated via interviews with experts. Alternatively group techniques can be used to help provide the basis for the process model.

### 6.2.4. Observation

Observational techniques are another valuable means of capturing tacit knowledge. These techniques are particularly useful when trying to capture special skills (e.g. calibration techniques, equipment set-up and operation, specialist welding etc.). Simply observing and making notes as the expert performs their daily activities can be useful, although this is a time-consuming process. Videotaping task performance can also be helpful, especially if combined with interviewing and other techniques. In general, simple observation techniques are rarely used, as they are an inefficient means of capturing the required knowledge.

#### 6.2.5. Constrained tasks

The constrained task approach limits the choices an expert is given when capturing knowledge. This technique is often used to capture 'key' knowledge and tasks from the expert that otherwise wouldn't be easily elicited by an interview. This can save time and can be an efficient use of the expert's time. Examples include structured interviews, self-assessment questionnaires, quizzes and guessing games.

#### 6.2.6. Concept sorting

Sorting techniques are a well-known method for capturing the way experts compare and order concepts. This can lead to the understanding of the knowledge about properties, tasks and relationships between concepts. A simple example is card sorting. Here the expert is given a number of cards each displaying the name of a concept. The expert has the task of repeatedly sorting the cards into piles such that the cards in each pile have something in common.

Variants of this involve sorting objects or photographs rather than cards (used where simple textual descriptions are not easy to use). The facilitator gains insights by asking appropriate questions about the relationships between concepts. This method is highly effective in helping to harvest deep tacit knowledge.

### 6.3. SOCIAL INTERACTION AND KNOWLEDGE SHARING TECHNIQUES

#### 6.3.1. Communities of practice

Community of practice (CoP) is a network of people who work on similar processes or in similar disciplines, and who come together to develop and share their knowledge in that field for the benefit of both themselves and their organization. The original thoughts behind the concept of a CoP are generally attributed to E. Wenger, and the techniques and benefits are described in his book [8].

CoPs are generally self-organizing and usually emerge naturally but need management commitment to get started and continue working effectively. They typically exist from the recognition of a specific need or problem and are particularly important in realising benefits in R&D organizations through increased innovation and collaboration.

A CoP provides an environment (face-to-face and/or virtual) to connect people and encourage the sharing of new ideas, developments and strategies. This environment encourages faster problem solving, cuts down on duplication of effort, and provides potentially unlimited access to expertise inside and outside the organization. Information technology now allows people to network, share and develop ideas entirely online. Virtual communities can thus help R&D organizations overcome the challenges of geographical boundaries.

#### 6.3.2. Peer assist

Peer assist is a process in which an individual or team arranges a meeting or a workshop in order to make use of the knowledge and experience of other individuals or teams before embarking on a project or activity. In R&D organizations the peer assist process can help avoid situations such as 're-inventing the wheel' and provides team members with valuable knowledge and insights from other teams before embarking on a project or task. It therefore allows a valuable connection with those seeking assistance with a peer group who have expertise in a given area. A peer assist meeting can last from an hour to a full day depending on the size of the project or activity.

Communicating with experienced peers about the best way to approach new projects saves R&D organizations time and money and avoids repetition of mistakes. It also helps to create strong team bonding, establishes rapport and fosters the development of relationships between people.

#### 6.3.3. Knowledge marketplace

A knowledge marketplace can be regarded as a 'dating service' to assist in knowledge and competence transfer. The process begins by identifying what people currently know and what they would like to know on a particular topic and then connects them as appropriate. The knowledge marketplace process can be facilitated face-to-face, on-line or via email. It can be used in many situations, for example, when delegating roles and responsibilities within a new project team. Success of the process depends on the willingness of the participants to both contribute and benefit in equal measure from exchanging knowledge and information. It is also highly dependent on the degree of trust between individuals.

In R&D organizations it can often be difficult to find people with the knowledge, skills and experience needed on a specific subject or process. Much useful, specialist knowledge remains untapped in many R&D organizations. The knowledge marketplace concept provides a means to discover and transfer this knowledge and make it available to others who need it.

A knowledge marketplace can be run as follows within a participating team or group:

(a) Each person should first identify their knowledge requirements — these could be areas where they feel there are gaps in their knowledge or areas requiring additional learning/experience.

(b) Each person then identifies their knowledge to offer — these would be areas where they have knowledge, skills or experience to share with others.

(c) A facilitator collects some basic information to start the 'connection and collection process', for example: name, job title, department/group, email address, topic. This information can be recorded in a form, an Excel spreadsheet, by email, or on a flip chart during the session. This information is then used to connect people to people and the sharing process can begin.

(d) The sharing process could simply involve having a conversation or discussion with another person. Where external organizations are involved, it could be exchanging business cards with people who have knowledge or experience of benefit to you. Alternatively, the sharing could happen after the event has been recorded and the relationships mapped out and made available.

#### 6.3.4. After action review

After action review (AAR) is a process used to capture and evaluate lessons learned. It takes the form of a quick and informal review and discussion at the end of a project or at a key stage within a project or other activity. It enable

— Decide what action should be taken next in similar situations.

The discussions should typically cover:

— What happened and why;

— What went well or better than expected;
— What development issues occurred that require improvement;
— What lessons can be learned from the experience for the next project.

In R&D organizations, much work results in the creation of new knowledge. By formalizing the way this knowledge is extracted and recorded, it can readily be made available to colleagues and other organizations facing similar challenges. AAR therefore provides a simple and quick way of making an informed decision about how to approach the next project or study.

#### 6.3.5. Knowledge café

A knowledge café brings people together to have an open, creative discussion on topics of mutual interest. It can be organized in a meeting or workshop format, but the emphasis should be on flowing dialogue that allows people to share ideas and learn from each other. It encourages people to explore issues in a novel or original way generating new understanding and ideas that can be used constructively in an innovative R&D environment. It also helps people network and make connections for future work activities and collaboration.

A knowledge café is run by a facilitator, who before the event considers the topic for discussion and invites appropriate participants to attend. During the knowledge café event, members arrange themselves in small groups and have an open exchange of ideas. It is normal for such discussions to last around 30–60 minutes. At the end of the group interaction, the facilitator asks each group in turn to summarize the main points of the discussion. Cross-fertilization of new ideas occurs and it is common practice for the facilitator to capture the key points raised and distribute the findings to all members at a later date.

### 6.4. IT TOOLS

#### 6.4.1. Document and content management systems

Document and content management systems have been used for many years to hold explicit knowledge in the form of documentation. Such systems are particularly important in R&D organizations to help maintain in electronic format items such as research papers, results of experiments, design information, component data, drawings and other data and information relating to the research centre and its operations. Most systems incorporate a workflow module that allows the circulation of documentation amongst users maintaining configuration control for document updates following check and approve cycles. Examples of the most frequently deployed systems include:

— Documentum (www.documentum.com);
— Hummingbird (www.hummingbird.com);
— Microsoft SharePoint (www.microsoft.com);
— FileNet (www.ibm.com);
— Livelink (www.opentext.com).

#### 6.4.2. Explicit knowledge search/retrieval

All types of nuclear R&D organizations require personnel to be able to search for and have access to explicit knowledge. Search engines such as Google have made search and retrieval much easier for general users on the internet but many R&D organizations do not allow staff the same functionality within the organization. A simple search engine is often included in the document/content management systems described in para 6.4.1 above. More frequently third party search facilities are integrated with such systems that allow full text retrieval across multiple file types. At the higher end of the scale it is also possible to search for information using systems that understand meaning, sometimes called contextual search capability. Given the diverse and often unstuctured nature of information in an R&D environment, contextual search capability is an IT feature worth considering.

### 6.4.3. Knowledge base systems

A knowledge-based system is a computer system that is programmed to imitate human problem solving by means of artificial intelligence and reference to a database of knowledge on a particular subject. The purpose of a knowledge base system is to:

— Allow knowledge to be stored and structured;
— Provide an interface with other IT systems that contain knowledge;
— Allow users to find and access knowledge;
— Carry out decision making and problem solving activities to replicate human thought processes.

In an R&D setting, knowledge base systems can be used to:

— Replace human intervention in some decision-making or trouble-shooting processes in a lab environment (examples include intelligent monitoring/fault diagnosis on large-scale equipment or experiments that require constant supervision);
— Store/preserve knowledge from experts for reuse at a future date (used in conjunction with the knowledge capture techniques described in para 6.2);
— Work faster than human processing for some activities that may require this (examples here include integration with reactor simulator systems to help model rapidly escalating transient situations);
— Assimilate information and integrate with other IT systems such as search engines, document/content management systems, portals and social networking systems as described in Section 6.

Some examples of knowledge base systems are given below, together with the links to the relevant internet sites:

— True knowledge (www.trueknowledge.com). An answer engine capable of answering questions put to it on any topic;
— Solvatio (www.iisy.de). A diagnostic tool, which combines case based reasoning and rules based reasoning together with a self-learning capability;
— Novo (www.novosolutions.com). Help Desk Software, Knowledge Base Software & Service Desk Software Solutions.

### 6.4.4. Portals

A portal is a comprehensive access structure to resources (web ‘super site’) that provides a single, often personalized interface point for accessing and consolidating information from disparate sources. The purpose of a portal is:

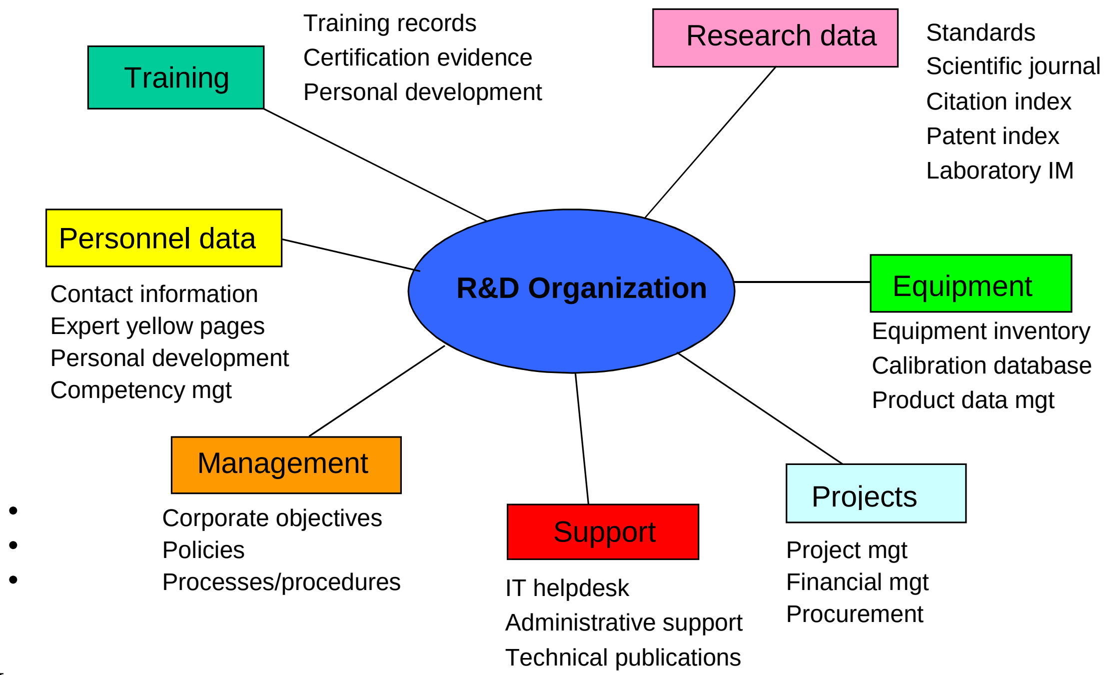
— An integration tool — to provide easy, unified and integrated access to an organization’s own resources;
— An access tool for other (internal and external) information resources;
— A communication tool — to enable individuals, teams and ‘communities of practice’ to share and discuss ideas and knowledge.

In and R&D organization a portal offers many advantages:

— Increases staff productivity (by reducing the time taken to access information and provide it in a more useful form.);

— Providing management with powerful data management tools (for an effective overview of performance and activities);
— More effective decision-making (based on access to needed knowledge);
— Recognition of the value of knowledge (as a key element of human capital with significant commercial value).

For an R&D organization, content for a portal might be organized as shown below in Figure 4.




**Notes:**
a) IM — information management.
b) mgt — management.

*FIG. 4. Example portal content for an R&D organization.*

The IAEA recognize that portals have an important and beneficial function in most nuclear organizations and have produced a guidance document that addresses the main development process [9]. Examples of software tools commonly used to develop portals include:

— IBM: WebSphere Portal Server (www.ibm.com);
— Microsoft: Microsoft Office SharePoint Server (www.microsoft.com);
— Oracle: WebLogic Portal (www.oracle.com);
— Oracle: WebCenter Suite (www.oracle.com);
— SAP: SAP NetWeaver Portal (www.sap.com);
— Sun: Sun Java System Portal Server (www.sun.com);
— Open Text:Vignette Portal (www.opentext.com);
— Broadvision: Broadvision Portal (www.broadvision.com).

### 6.4.5. Collaboration and social networking tools

Enterprise social software, also known as Enterprise 2.0, is a term describing social software used in an enterprise (business) context. Examples of social software include Facebook, Myspace, Flickr, Wikipedia etc. and these systems are generally used by individuals outside the work environment. Figure 5 below shows the relationship between Web 2.0, the enabling technologies and the Enterprise 2.0 concepts and tools used for business.

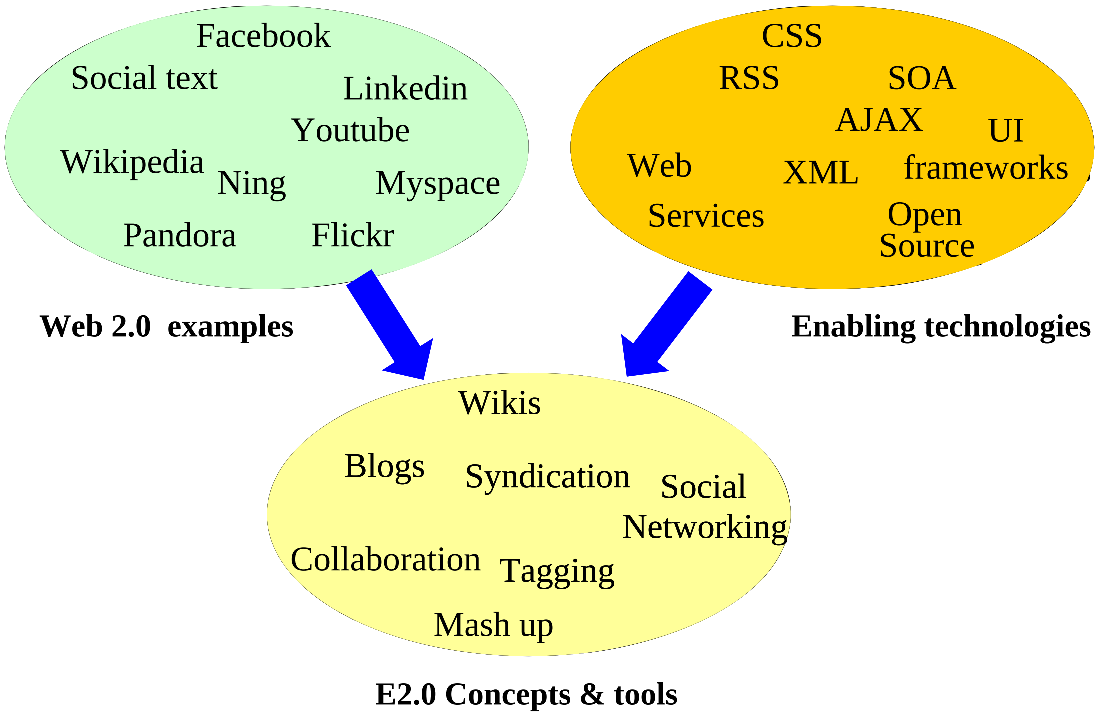



*FIG. 5. Enterprise 2.0 and social networking.*

In an R&D setting it is possible to use adaptations of social networking tools to support knowledge sharing within the organization. The advantages that this brings include:

— Improved collaboration — leading to increased knowledge sharing between individuals and teams;
— Innovation — helps to break down silos an open up new connections between teams;
— Productivity — opens up networks within the organization improving both the quantity and quality of work.

One of the best examples of an Enterprise 2.0 tool is a wiki. A wiki is a page or collection of web-pages designed to enable anyone with access rights to contribute or modify content using a simplified mark-up language. Specific benefits for R&D organizations include:

— Allows easy capture and sharing of information;
— No programming or software skills needed by the content provider (user);
— Better and faster real time collaboration among employees;
— Can cut down on email and the need to forward attachments;
— Can reduce the need for meetings.

Currently, there are very few R&D organizations using Enterprise 2.0 tools but the numbers are expected to increase as the concept becomes more widespread and accepted in other business sectors.

Example vendors/products active in this market include:

— Jive Software: Jive SBS (www.jivesftware.com);
— Awareness: Awareness Social Media Marketing platform (www.awarenessnetworks.com);
— Socialtext: Socialtext Collaboration Platform (www.socialtext.com);
— Microsoft: Sharepoint Server (www.microsoft.com);
— IBM: Lotus Connections (www.ibm.com);
— Oracle: Oracle Web Centre Suite (www.oracle.com).

### 6.4.6. Skills/competency management systems

For nuclear R&D organizations, demonstrating staff competence to regulators and clients in a very important management practice. A related activity is the actual process of maintaining and enhancing competence throughout the entire organization. IT tools are available to help do this. The functionality of most systems available on the market allows:

- The management of personnel data (name, address, job position, qualifications, certifications, experience etc.);
- The construction of competency frameworks;
- Allocation of competencies to roles;
- Competence of individuals to be recorded;
- Training requirements to be allocated and training records maintained;
- Role and task information to be captured;
- Gap analysis reporting

For R&D organizations, the advantages of implementation of such a system include:

- Means of measuring and thus improving competence in a systematic manner;
- Enables expert competencies to be identified and made available to others in the organization;
- Tangible demonstration of staff competence to clients and regulators, thus assuring regulatory compliance in this area;
- Enables cost effective planning of training across the organization;
- Validity periods for refresher and update training are provided with automatic warnings of expiry;

Some examples of skills/competency systems are given below, together with the links to the relevant web-sites:

- Tritaium: SkillsXP (www.tritanium.com);
- Avilar: Web Mentor Skills (www.avilar.com).

# 7. A ROADMAP FOR SUCCESSFUL IMPLEMENTATION

## 7.1. FIVE STAGE IMPLEMENTATION PROCESS

Like any other initiative within an organization, successful implementation of a KM project requires proactive management through a number of development stages. For KM projects, a five -stage process is applicable as depicted by Fig. 6 below. Each of the five stages is described in the paras that follow.

### 7.1.1. Stage 1 — Orientation

Orientation involves the understanding of basic KM concepts and the understanding of how KM can help drive change and increase organizational performance. The IAEA has done much to assist in this area and have produced significant reference material to help the initiation and education of managers and practitioners at all levels. In addition to the documentation listed in the References section of this publication, the IAEA has undertaken other initiatives to help with the understanding of KM concepts and the application of best practice. Such initiatives include:

- School of Nuclear Knowledge Management (currently held every year in Trieste, Italy);
- IAEA KM Assist Visits (these are described in more detail in Section 9 of this publication).

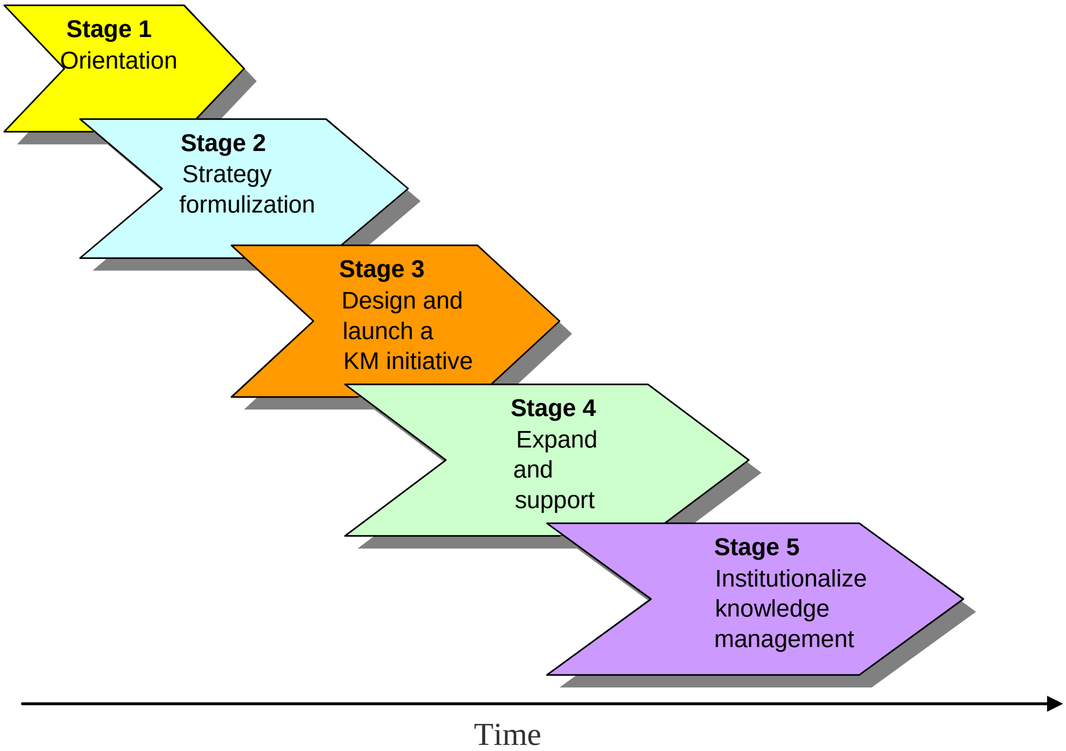



*FIG. 6. Five stage KM implementation process.*

It is extremely important that managers and sponsors understand what KM actually is, understand how benefits can be achieved and have a basic understanding of the techniques that can be used to facilitate improvement.

Orientation may take several months to organize and deliver. A useful exercise at this stage is to benchmark the current KM maturity of the organization. The IAEA maturity tool discussed in Appendix provides a means of achieving this.

### .1.2. Stage 2 — Strategy formulization

During this stage the organization begins to make plans on how to utilize KM approaches to help deliver the intended improvements or change. A good starting point here is to put together a KM policy or set of policies that will underpin future activities. This is similar to the approach that organizations use to implement formal quality management systems; in fact some organizations extend the existing quality assurance (QA) or human resources (HR) policies to address KM issues. Alternatively, a stand-alone KM policy can be prepared. Both approaches are equally valid and have their own merits. The main aim of this policy stage is to:

— Consolidate initial ideas;
— Communicate these ideas to others in the organization;
— Gain commitment from senior managers;
— Prepare the ground for stage 3 and future stages.

The policy document(s) contain top-level ideas and organizational beliefs but more detail is needed for the overall strategy and approach to be viable. This is best described by the creation of a separate strategy document or business plan that can be used as a means to guide a particular project or a series of future initiatives. This publication will usually be established by a group of senior managers responsible for the initiative and will involve many detailed discussions, meetings and workshops aimed to capture ideas from the main decision makers in the organization. The typical contents of a business plan or strategy document required to ‘kick-start’ a KM initiative or project may comprise:

(1) Executive summary;
*Brief, one page summary of the initiative.*

(2) Introduction;
*Describes what the initiative is, why it is needed and why/how applying KM concepts can help the organization. KM terminology should be introduced and explained here.*

(3) Business opportunity and benefits;
*Outlines the quantitative and qualitative benefits to be gained from the implementation.*

(4) Resources;
*Describes what resources i.e. people, equipment, money, will be needed for the initiative.*

(5) Outline implementation plan;
*Describes the approach, methodologies, technical solutions, team responsibilities, external assistance, timescales etc. for implementation.*

(6) Risk analysis;
*Considers the main risks of implementation and the mitigation actions needed to address these risks.*

(7) Appendices;
*Information required supporting where necessary.*

Once available in draft form it is necessary to distribute the document to all participants involved in the process to gain as much support as possible before the KM project launch process begins.

### 7.1.3. Stage 3 — Design and launch

A successful KM implementation requires a number of prerequisites to be in place at the start of a project. These include, but are not limited to:

— Does the project align with organizational needs?
— Is the purpose of the project clearly defined?
— Are the benefits understood and well communicated?
— Is there top-level management support/commitment?
— Is there a senior management sponsor?
— Is a project manager assigned?
— Are resources made available?
— Is there sufficient ‘know how’ in the project team?
— Is the knowledge sharing culture of the organization understood and receptive to the needs of the project?

Much of the above should have already been discussed and agreed during phase 2, however, there may have been changes or a significant delay in starting the project since phase 2 and some of these aspects may need to be revisited.

A project specific plan should be developed which describes the project aims and objectives together with a timed plan of tasks and details of resource requirements. The template discussed in para 7.1.2 can be developed and used for this purpose. The project should be run as an internal change initiative requiring buy-in and support from top-level management. The exact details of the plan will vary from project to project but will need to reflect the benefits sought and the KM tools and methodologies to be used.

Many initiatives at this stage involve the concept of a pilot project, i.e. a project with limited scope used to test the tools and methodologies before a full roll out commences.

### 7.1.4. Stage 4 — Expand and support

Stage 4, ‘Expand and support’, builds on the project launch in Stage 3 and continues with the further implementation of KM in the organization. If a pilot project is adopted in Stage 3, then lessons learned from this project are important inputs to this stage.

Expanding the KM capability of the organization can be done in a number of different ways, e.g.:

— Roll out of the tools and methodologies used in Stage 3 into other, additional areas or departments of the R&D organization;
— Extension of the KM tools and methodologies;
— Implementation of new or additional KM tools and methodologies.

This expansion of functionality will invariably lead to the requirement for additional budget and resources. Further support from senior management will also be needed to ensure that the initiative is correctly focused and does not falter.

If there are multiple KM initiatives to deliver in parallel it may be necessary to consider the adoption of a ‘programme management’ approach. This considers the cross project links between the various initiatives and addresses aspects such as interdependencies and priorities. Programme management is a topic in its own right and is outside the scope of this publication.

### 7.1.5. Stage 5 — Institutionalize knowledge management

This stage is reached when multiple KM projects have been realized after many years of effort. KM techniques and approaches become a normal part of organizational activities and can be found, for example, integrated into the QA system (see Section 8). Cultural issues that may have existed following the introduction of KM projects will have been resolved and the organization will have a positive view of KM and its benefits. To reach this stage is not the end for KM in the organization but rather the beginning as with any other process; KM becomes part of the integrated management system and needs to be maintained within the cycle of continuous improvement.

## 7.2. GOVERNANCE AND PROJECT REPORTING STRUCTURES

Governance for a KM project relates to consistent management, implementing cohesive policies, establishing appropriate methods/tools and providing the means of empowerment for a given area of responsibility. These should be derived and communicated via the strategy documents and project plans described above in stages 2 and 3.

The set up and reporting aspects for a KM project are very important and also relate to governance issues. Figure 7 shows the typical reporting structure that might apply to any kind of R&D organization looking to implement a KM project.
The project sponsor is a key member of top management with decision making powers inherent in his or her main role.

The IT development team and Process development team typically come from the IT Department and QA Department respectively (but this need not be the case). Process development is an important aspect as most KM projects will result in a new way of working for many employees.

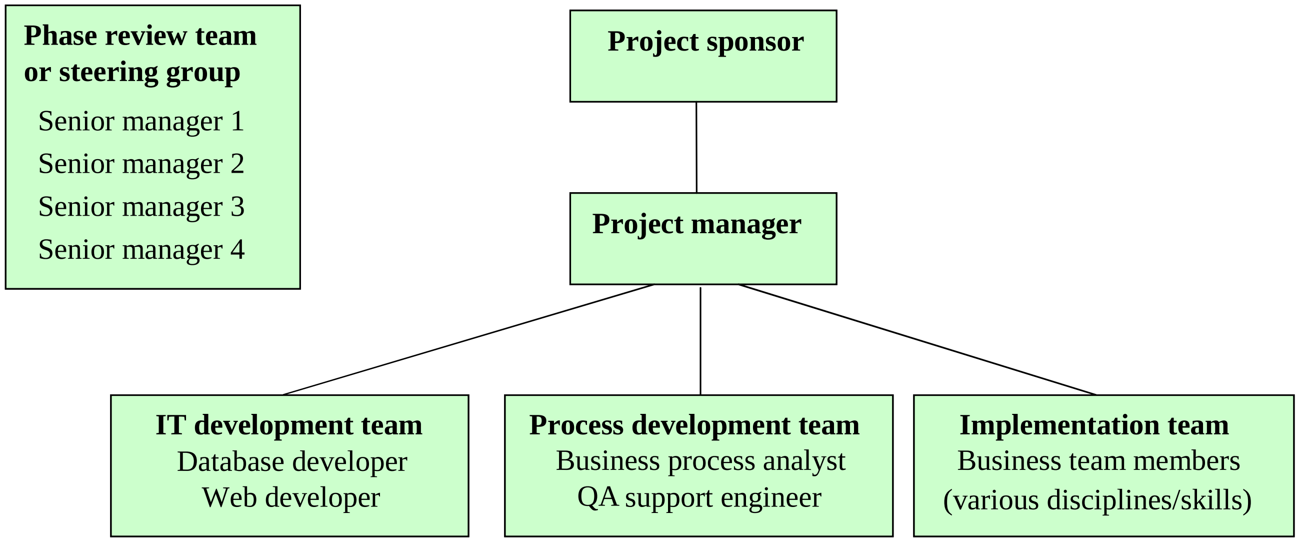



*FIG. 7. Typical KM project reporting structure.*

The Implementation team should come from the area(s) of the organization where the project is to be implemented. This could be department, group or location based. This is a very important representative group as the project success or failure will dependent on how well the recipient group implement and derive benefit from the initiative.

A Phase review team is an independent team of senior managers who scrutinize the project and ensure alignment with the R&D business. They meet on a regular basis (perhaps 3–4 times during the duration of the project).

Some KM projects may also require specialist input from other departments such as Human Resources, Training, and Administration etc. It is important to select the most appropriate team structure and individuals to meet each project's specific needs.

## 7.3. AVOIDING COMMON PITFALLS

The following sections describe some common pitfalls that should be avoided when running a KM project. The list is not exhaustive and tries to address all types of project in all types of R&D organization.

### 7.3.1. Insufficient management commitment

Not establishing or gaining support from senior management remains the number one reason why many KM and IT projects fail to deliver their main objectives and benefits. This aspect is raised several times in this publication. Support in this context means more than just signing a policy document, it means proactively taking part in discussions and using influence to overcome objections or other problems that might affect the project outcome. When establishing a KM project it is imperative to have allies at the top level in the organization willing to fight for the cause. Without this support there is a very high likelihood of failure.

### 7.3.2. Incorrect business alignment

The implementation of KM initiatives that are not aligned to business needs will also inevitably lead to a high probability of failure. Alignment means relating KM methods and tools with the benefits that can be gained from their adoption. Figure 8 below shows how alignment might work in practice, with a clear 'line of sight' from the KM techniques to the benefits realized.


*FIG. 8. Alignment of KM with the top level goals of the organization.*

The creation of an equivalent model, tailored to the needs of the organization is a useful checkpoint for establishing correct alignment and project success.

#### 7.3.3. Underestimating resource requirements

A common mistake that organizations make is to underestimate the resources needed for a successful KM implementation. The resources described here relate to the money and manpower required for effective delivery of projects. The main problem seems to relate to manpower. As KM is a people related topic, much effort is needed by:

(a) The project team to implement the KM tools/techniques;
(b) The experts in the organization who are often needed as part of the knowledge transfer process.

Although full time commitment to the project is not required throughout its duration, a significant proportion of time should be allocated and agreed with line managers before commencement. This may require some key individuals to temporarily suspend tasks or to delegate tasks to others whilst taking part in the project.

#### 7.3.4. Failing to address cultural issues

Failing to address the significance of cultural issues is another area that many organizations often neglect. KM projects, by their nature, involve people sharing and collaborating with others. If the conditions are not conducive in the organization for knowledge sharing then this can be a major issue and a barrier to implementation. Understanding and changing organizational culture is a topic in its own right and beyond the scope of this publication to consider. However, many of the problems can be avoided at project inception by selecting project members and experts who already possess qualities and beliefs that promote the sharing of knowledge.

#### 7.3.5. Poor communication

Failing to communicate the objectives, benefits, methodologies and other aspects of the project to all in the organization can also lead to a difficult implementation. Every opportunity should be used to communicate using channels such as notice boards, web-sites, email, team meetings, newsletters etc. Increased leverage for the project can also be gained by communicating the aims of the project to clients, contractors and partnering organizations.

As the project progresses it is also important to provide updates regarding milestones achieved and other significant accomplishments. An upbeat, positive approach works well that takes into account the other success factors in this section.

#### 7.3.6. Underestimating implementation timescales

KM projects need considerable effort to establish and run. In many cases the tools and techniques will be unfamiliar and time consuming to manage. In addition to this, a new way of working may be required that takes participants longer than expected to master. These effects, combined with the resourcing issues discussed above, mean that most projects run late or behind the targeted programme. Delays invariably result in additional spend and frustration for participants. These problems should be envisaged when the project begins and adequate margins built into the programme. A key learning point is always to expect KM initiatives to take longer than might initially be expected.

## 8. LINKS WITH THE QUALITY MANAGEMENT SYSTEM

Many R&D organizations operate a certified management system to the requirements of ISO 9001 (quality) and ISO 14001 (environmental). One question that is often asked is “how does the organization integrate knowledge management strategies, processes and systems into the existing management system?” This can be achieved in a number of ways; examples of alternative strategies are given below.

### 8.1. CREATING A STANDARD FOR KM

There is currently no ISO standard for KM. One useful strategy is to ‘invent’ a standard for KM based on the ISO philosophy. On this basis a KM standard would be expected to address aspects such as:

- Policy;
- Objectives and targets;
- Resources;
- Training and awareness;
- Communication;
- Controls;
- Monitoring and measurement;
- Audits and management review.

By addressing the above requirements a systematic structure will emerge that will enable an organization’s KM activities to be readily assimilated into the existing management system.

### 8.2. HIGH LEVEL INTEGRATION OPTIONS

ISO 9001 requires a process approach to be adopted by certified organizations. Many R&D organizations have done this for several years and have developed high-level process models that describe their core activities. A ‘drill-down’ approach is usually used to access more detail and this continues down to individual procedures and work instructions that are used by staff. One approach for KM integration into the management system involves defining KM as a core process and including this as a top-level management process. This is illustrated by Fig. 9 below.

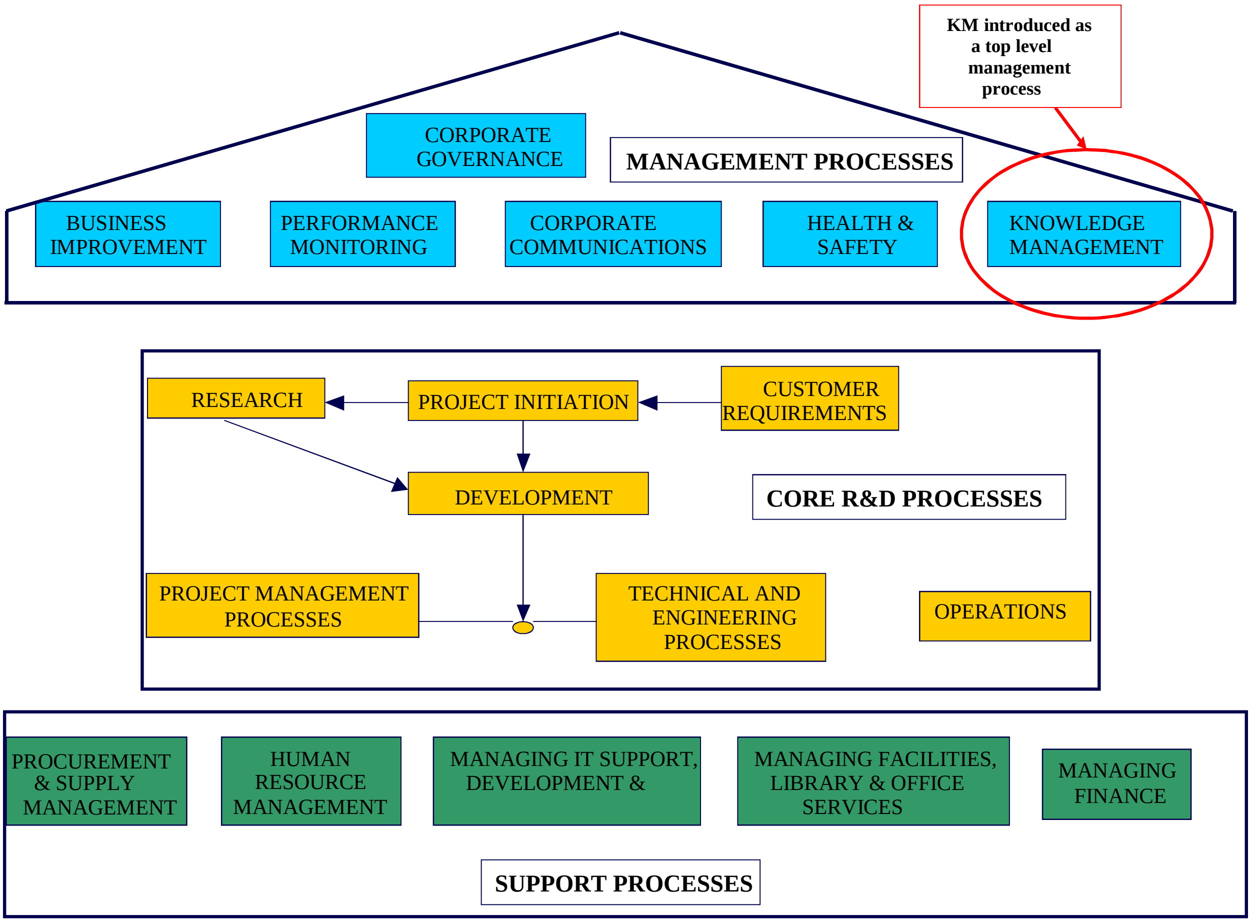



*FIG. 9. Introducing KM as a major component of the management system.*

The main advantage of this approach is that KM is immediately elevated to a core business activity. As a central element of the management system, KM will receive attention, review and audit both internally and externally. This in turn will automatically lead to top-level management attention needed for success and further improvement.

The main disadvantage of this approach is that there is a major implementation programme needed for effective delivery. KM processes need pre-defining and integrating into the existing system; most organizations will need to consider new processes (or formally document existing KM processes). A high level of resource will be needed for successful delivery and the organization will need to adopt a formal change management approach to ensure all staff is receptive to the new ways of working.

## 8.3. INTEGRATION AT THE WORKING LEVEL

This approach recognizes that the organization is already carrying out KM activities as part of its normal function but not necessarily labelling these as KM. Such activities may include knowledge transfer aspects e.g. coaching, mentoring, learning from experience, training, succession planning etc. The methodology adopted recognizes these activities form part of the organization's KM strategy but leaves them unaltered with the same ownership. The KM strategy would identify new initiatives and try to integrate these into the existing system but not at the top management level.

The main advantage of this approach is with the ease of implementation. The transition from existing to new KM initiatives is less demanding on people's time and the resources needed for making the change are modest compared with the approach outlined in para 8.2 above.

The main disadvantage of this working level approach is that KM can be seen as not core to the organization's activities and thus receive less attention and support from senior management.

## 9. HELP THROUGH THE IAEA IN THE ESTABLISHMENT AND MATURITY ASSESSMENT OF NKM PROGRAMME

In 2005, the IAEA introduced the concept of KM assist missions to help NPPs and other nuclear operating organizations understand KM and implement KM initiatives. The missions were established to support sub programme C.3 and:

- Help organizations identify, by self-assessment, their own KM maturity levels against a set of pre-defined criteria;
- Assist organizations formulate detailed requirements and action plans related to KM;
- Facilitate the transfer of pragmatic KM methodologies and tools;
- Provide specific consultancy services to address emergent problems and long term issues related to KM and associated issues;
- Assist Member States considering implementation of nuclear power programmes to integrate KM in their management system from the very beginning.

The assist mission concept was originally geared towards NPPs but has now been extended to include other nuclear organizations, including nuclear R&D organizations. Details of the enhanced maturity model specifically designed for R&D organizations, using a self-assessment approach, can be found in Appendix of this report.

Nuclear R&D organizations that want to explore the possibility of introducing the KM concepts, methodologies and tools discussed in this report should consider help from the IAEA by requesting an assist mission. The process for required to initiate this can be found in Ref. [5].

## 10. CONCLUSIONS AND RECOMMENDATIONS

This publication is written to help nuclear R&D organizations understand the main principles of NKM and for such organizations to gain benefit from the introduction of a NKM programme. It addresses the needs of different types of nuclear R&D organization and describes the process for establishing a NKM programme from first principles. The publication is not intended to be a fully comprehensive guide to NKM methodologies and techniques but instead provides a general overview of the tools and techniques that might be adopted to gain business benefit in an R&D environment.

The main methodologies and tools discussed are summarized below:

- KM analysis tools (including a maturity model intended specifically for R&D organizations);
- Knowledge capture techniques;
- Social interaction and knowledge sharing techniques;
- IT tools.

Most nuclear R&D organizations already have a quality management system that underpins its operations. An important consideration is the integration of NKM practices into the quality management system. This aspect is considered and options are explored which help to provide a practical means of achieving such integration.

A roadmap for successfully delivering a NKM programme is provided that considers a five stage process for implementation. This programme is considered valid for all types of nuclear R&D organization.

Finally, when considering a NKM programme, nuclear R&D organizations can seek or request IAEA assistance at any point in the implementation process. This publication provides reference material and identifies sources of information to assist organizations obtain this help.

## Appendix

## KNOWLEDGE MANAGEMENT ASSESSMENT TOOL FOR R&D ORGANIZATIONS[1]

### A.1. KNOWLEDGE MANAGEMENT REVIEW CRITERIA

The self-assessment methodology described here is intended to provide R&D organizations, in particular senior management, with the status of their current KM efforts compared with what should be in place (extent currently utilized vs. desired extent).

Individual criteria have been identified that are considered as key elements towards an effective approach to KM. The criteria have been grouped into eight organizational or functional categories, to facilitate the self-assessment, via:

(1) Policy/strategy;
(2) Human resource (HR) planning and HR processes;
(3) Competence development
(4) Methods, procedures & documentation processes for improving KM;
(5) Technical (IT) solutions;
(6) Approaches to capture/use tacit knowledge;
(7) KM culture/workforce culture supporting KM;
(8) External collaboration.

Metrics for the overall self-assessment and for each individual category have been developed as shown in Table 1:

TABLE 1. KM SELF-ASSESSMENT METRICS SCORING

| Rating | Extent currently | Extent should be |
|---|---|---|
| 0 | Not utilized at all | Not utilized at all |
| 1 | To a little extent | To a little extent |
| 2 | To some extent | To some extent |
| 3 | To a great extent | To a great extent |
| 4 | To a very great extent | To a very great extent |

A self-assessment questionnaire has been developed based on the above eight categories. A Microsoft Excel based tool is also available that is used to facilitate the self-assessment process. The tool uses radar/spider diagrams for each of the eight functional categories and at an executive summary level to give management a graphical depiction of current KM strengths and future development areas. An example of the output is given on Fig. 10 below:

Self-assessment can be used independently by a nuclear R&D operating organization for an internal review, as a prerequisite for a KM assist mission or during a KM assist mission. These criteria are not so much intended to provide a 'report card' as they are to assist managers in identifying strengths to build upon and areas for improvement to be addressed in the knowledge management area.

[1] Knowledge management assessment tools are developed by the IAEA for different types of nuclear organizations. The tool for nuclear industry operating organizations is presented in Ref. [5]. Although the tools use similar methodologies the nature of R&D organizations dictates some specific which has been taken into consideration and properly addresses in the entire document.

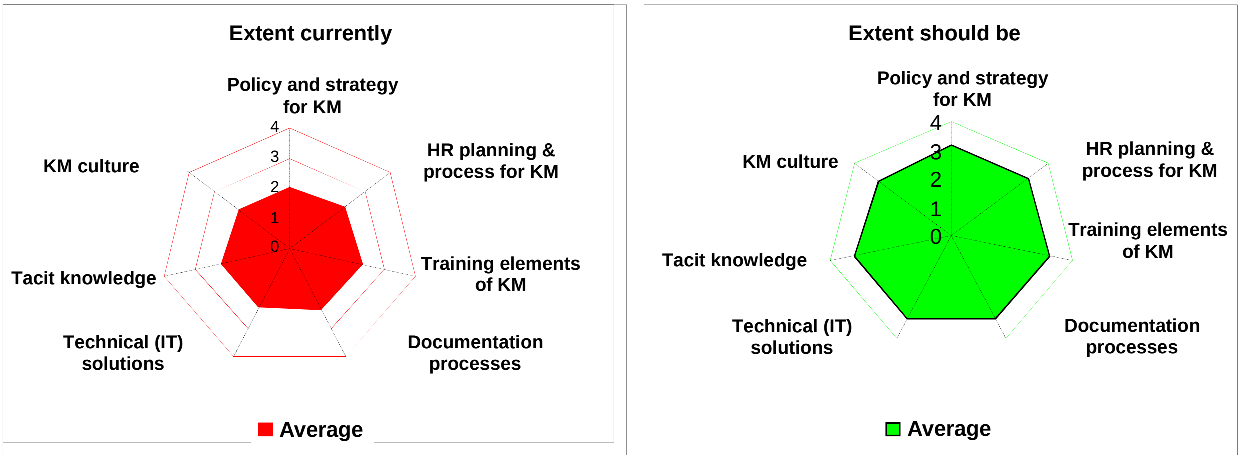



*FIG. 10. Sample output of the present and desired maturity of an NKM programme.*

TABLE 2. INTRODUCTORY QUESTIONS — TO BE ASKED BEFORE THE ASSIST VISIT BEGINS

| No | Key words | Description of criteria | Areas of research: Basis research | Applied research | Design R&D | Nuclear R&D facilities | Non-nuclear R&D facilities | Technical support & services | Education | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Activity domains | What activity domains do you have in your institute? | | | | | | | | |
| 2 | Activity domains | What percentages of total funds are allocated to each domain? | | | | | | | | |
| 3 | Activity domains | What percentage of research staff are involved to each domain? | | | | | | | | |
| | | | Yes | No | | | | | | |
| 4 | Activity domains | Is the organogram provided? | | | | | | | | |
| 5 | Strategy | Do you have a long term strategy for the organization? | | | | | | | | |
| | | | Structure of funds | | | | | | | |
| No | Key words | Description of criteria | National public funding | International funding | NPP and utility funding | Regulator | Other | Other | Other | Comments |
| 6 | Funding | What are your sources of funding (in percentage)? | | | | | | | | |
| No | Key words | Description of criteria | Knowledge domains | | | | | | | Comments |
| 7 | Knowledge domains | Please list your knowledge domains! (e.g. reactor physics, thermo hydraulics, radiation protection, nuclear engineering, radiations chemistry, I&C, etc.) | | | | | | | | |

### A.2. POLICY/STRATEGY

This topic covers the following aspects:

— Written policies/strategies;
— Communication strategy;
— Identification of KM responsibilities.

(For background information see Refs [1, 2, and 5]).

TABLE 3. POLICY/STRATEGY QUESTIONNAIRE

| No | Description of criteria | Extent currently | | | | | Extent should be utilized | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 4 | |
| 1 | Does the organization have a written policy for implementing its strategy in KM area? | | | | | | | | | | | |
| 2 | Is this KM policy integrated into the management system? | | | | | | | | | | | |
| 3 | Is a KM policy communicated to all staff in the organization? | | | | | | | | | | | |
| 4 | Are those responsible for managing the formulation and implementation of the organizations KM strategy clearly identified? | | | | | | | | | | | |
| 5 | Does the organization's strategic focus support continuous learning to improve individual and organizational performance? | | | | | | | | | | | |
| 6 | Is the organization's KM policy aligned with continued emphasis on a strong safety culture? | | | | | | | | | | | |

### A.3. HUMAN RESOURCE PLANNING & HR PROCESSES

This topic covers the following aspects:

— Workforce planning;
— Succession planning;
— Risk assessment for critical knowledge loss;
— Employee development plans for KM.

(For background information see Refs [1, 2, and 5]).

### A.4. TRAINING AND HUMAN PERFORMANCE IMPROVEMENT

This topic covers the following aspects:

— Coaching and mentoring;
— SAT;
— Simulator use;
— CBT (e-learning);
— Human performance improvement.

(For background information see Refs [1, 2, and 5]).

TABLE 4. QUESTIONNAIRE FOR HUMAN RESOURCE PLANNING & HR PROCESSES

| No | Description of criteria | Extent currently utilized | | | | | Extent should be utilized | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 4 | |
| 1 | Does the organization implement a comprehensive methodology to ensure that HR needs both current and future are met (work force planning)? | | | | | | | | | | | |
| 2 | Is there a succession planning programme in place? | | | | | | | | | | | |
| 3 | Are risk assessments carried out to identify potential loss of critical knowledge and skills? | | | | | | | | | | | |
| 4 | Are exit interviews carried out to capture critical knowledge and experience when people leave the organization? | | | | | | | | | | | |
| 5 | Does a programme exist to develop new leadership /technical talent in a timely manner? | | | | | | | | | | | |
| 6 | Does the organization utilize job profiles or equivalent to assess and monitor its skills/competency needs? | | | | | | | | | | | |

TABLE 5. QUESTIONNAIRE FOR TRAINING AND HUMAN PERFORMANCE IMPROVEMENT

| No | Description of criteria | Extent currently utilized | | | | | Extent should be utilized | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 4 | |
| 1 | Does the organization incorporate formal systematic approach to training (SAT) principles into its training programmes? | | | | | | | | | | | |
| 2 | Does the formal SAT programme address capture and dissemination of knowledge? | | | | | | | | | | | |
| 3 | Does the training programme utilize appropriate tools such as simulators, computer based training (CBT), multi-media simulations, etc. to capture/transfer critical knowledge? | | | | | | | | | | | |
| 4 | Is competence evaluated on a regular basis? | | | | | | | | | | | |
| 5 | Is regular refresher training carried out to maintain and enhance competence? | | | | | | | | | | | |
| 6 | Does the organization have a formal human performance improvement programme to maintain and enhance competence? | | | | | | | | | | | |
| 7 | Are coaching and mentoring approaches used to support knowledge sharing? | | | | | | | | | | | |

## A.5. METHODS, PROCEDURES & DOCUMENTATION PROCESSES FOR IMPROVING KM

This topic covers the following aspects:

- Learning from Operating Experience
- Work control methods
- Error prevention
- Document control/Configuration
- Corrective action programme
- Benchmarking

(For background information see Refs [1, 2, and 5]).

TABLE 6. QUESTIONNAIRE FOR METHODS, PROCEDURES & DOCUMENTATION PROCESSES FOR IMPROVING KM

| No | Description of criteria | Extent currently utilized | | | | | Extent should be utilized | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 4 | |
| 1 | Are KM methods incorporated into procedures and processes rather than being separate add-on tasks? | | | | | | | | | | | |
| 2 | Does the organization have a comprehensive methodology that addresses learning from experience? | | | | | | | | | | | |
| 3 | Are self-assessments regularly used to enhance organizational knowledge? | | | | | | | | | | | |
| 4 | Is external benchmarking regularly used to enhance organizational knowledge by adopting good industry practices? | | | | | | | | | | | |
| 5 | Is the feedback (internal and external) from operational experience (lessons learned), used by the organization for corrective action planning to achieve improvements? | | | | | | | | | | | |
| 6 | Is the composition of work teams (such as individual expertise/experience) considered in order to enhance knowledge transfer? | | | | | | | | | | | |
| 7 | Are all work activities documented in such a way that knowledge can be effectively retrieved, shared and utilized? | | | | | | | | | | | |
| 8 | Are procedures, drawings, lesson plans and related documentation updated promptly in a systematic way to address technical and organizational changes? | | | | | | | | | | | |

## A.6. TECHNICAL (IT) SOLUTIONS

This topic covers the following aspects:

- Knowledge data bases;
- Content/document management systems;
- Search engines;
- Portals/Intranet;
- Wikis/blogs;
- Skill/competency databases;

— Expert yellow pages;
— Enterprise resource planning (EPR);
— Other IT supporting systems.

(For background information see Refs [1, 2, and 5]).

TABLE 7. TECHNICAL (IT) SOLUTIONS QUESTIONNAIRE

| No | Description of criteria | Extent currently utilized | | | | | Extent should be utilized | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 4 | |
| 1 | Are IT and KM strategies aligned? | | | | | | | | | | | |
| 2 | Is the organization utilizing an integrated approach in managing its information? | | | | | | | | | | | |
| 3 | Does the organization utilize appropriate IT support systems and tools? In particular: | | | | | | | | | | | |
| | • Content/document management; | | | | | | | | | | | |
| | • Concept mapping; | | | | | | | | | | | |
| | • Knowledge databases; | | | | | | | | | | | |
| | • Simulation tools; | | | | | | | | | | | |
| | • Enterprise resource planning; | | | | | | | | | | | |
| | • Portals/Intranets; | | | | | | | | | | | |
| | • Knowledge search engines; | | | | | | | | | | | |
| | • Expert yellow pages; | | | | | | | | | | | |
| | • Expert systems; | | | | | | | | | | | |
| | • Wikis/blogs; | | | | | | | | | | | |
| | • Others? | | | | | | | | | | | |

### A.7. APPROACHES TO CAPTURE/USE TACIT KNOWLEDGE

This topic covers the following aspects:
— Taxonomy development;
— Process for critical knowledge ID;
— Processes for knowledge elicitation/harvesting;
— Concept mapping;
— CoPs;
— Coaching & mentoring.

(For background information see Refs [1, 2, and 5]).

### A.8. KM CULTURE/WORKFORCE CULTURE SUPPORTING KM

This topic covers the following aspects:
— No blame environment;
— Sharing knowledge;
— Leadership/commitment.

(For background information see Refs [1, 2, and 5]).

TABLE 8. QUESTIONNAIRE FOR APPROACHES TO CAPTURE/USE TACIT KNOWLEDGE

| No | Description of criteria | Extent currently utilized | | | | | Extent should be utilized | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 4 | |
| 1 | Does the organization utilize methods to identify people who have critical knowledge? | | | | | | | | | | | |
| 2 | Does the organization adopt effective techniques to capture critical knowledge such as: | | | | | | | | | | | |
| | • Elicitation interviews; | | | | | | | | | | | |
| | • Video capture; | | | | | | | | | | | |
| | • On-job training (OJT) dialogue; | | | | | | | | | | | |
| | • Mentoring/coaching; | | | | | | | | | | | |
| | • COPs; | | | | | | | | | | | |
| | • Explicit capture (narrative documentation); | | | | | | | | | | | |
| | • Card sorting (manual concept map); | | | | | | | | | | | |
| | • Concept mapping; | | | | | | | | | | | |
| | • Process mapping; | | | | | | | | | | | |
| | • Story telling; | | | | | | | | | | | |
| | • Others? | | | | | | | | | | | |
| 3 | Is information and data retained and presented in an effective way to facilitate search and retrieval? | | | | | | | | | | | |
| | effective transfer and utilization of captured knowledge? | | | | | | | | | | | |

TABLE 9. QUESTIONNAIRE FOR KM CULTURE/WORKFORCE CULTURE SUPPORTING KM

| | | Extent currently utilized | | | | | Extent should be utilized | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 0 | 1 | 2 | 3 | 4 | |
| 1 | Does the culture of the organization promote the sharing and transfer of knowledge, particularly tacit knowledge, amongst personnel? | | | | | | | | | | | |
| 2 | Does the organization have an open, no blame approach to reporting incidents/events and sharing from lessons learned? | | | | | | | | | | | |
| 3 | Is sharing of knowledge in the organization recognized and rewarded? | | | | | | | | | | | |
| 4 | Do managers lead by example performing practical, visible leadership supporting the knowledge management strategy? | | | | | | | | | | | |
| 5 | Do managers encourage trust, cooperation and collaboration between individuals and teams? | | | | | | | | | | | |

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## ABBREVIATIONS

| | |
|---|---|
| AAR | after action review |
| AJAX | Asynchronous JavaScript + XML |
| ANENT | Asian Network For Education in Nuclear Technology |
| CBT | computer based training |
| CDM | critical decision method |
| CoP | community of practice |
| CSS | cascading style sheets |
| EPR | enterprise resource planning; |
| FBTR | fast breeder test reactor |
| HR | human resources |
| IAEA | International Atomic Energy Agency |
| INIS | International Nuclear Information System |
| IP | intellectual property |
| ISO | International Standards Association |
| IT | information technology |
| KM | knowledge management |
| NKM | nuclear knowledge management |
| NPP | nuclear power plant |
| OJT | on-job training |
| QA | quality assurance |
| R&D | research and development |
| RER | rapid evidence review |
| RPA | radiation protection advisor |
| RSS | really simple syndication |
| SAT | systematic approach to training |
| SME | subject matter expert |
| SOA | service oriented architecture |
| UI | user interface |
| WNU | World Nuclear University |
| XML | extensible mark-up language |

**Annex**

**DEFINITIONS OF TERMS IN THE FIELD OF NUCLEAR KNOWLEDGE MANAGEMENT**

The following definitions apply specifically to the field of knowledge management. It should be noted that identical terms applied to, or used in, other fields may have somewhat different definitions. More definitions on the subjects can be found in Refs [1, 5] of this publication.

### after-action review

A process that involves conducting a structured and facilitated discussion after a task or project has been completed to review what should have happened; what actually happened; and, where differences exist, why it happened. Also termed *post-job briefing*.

*Comment*: After-action review allows participants to learn how to sustain strengths and improve on weaknesses in subsequent tasks or projects. It is used to help teams to learn quickly from their successes and failures and share their learning with other teams.

### asset management

An approach to responsible management of an enterprise that considers, in a balanced fashion, the entirety of its resources; these include tangible assets such as personnel and other animate creatures, facilities, equipment, fiscal investment, inventory, and intangible assets such as goodwill and intellectual capital.

*Comment*: Approaches such as the balanced scorecard can be employed to assure appropriately distributed attention to the whole of an organization's resources. In the nuclear industry, the combination of increased retirements and a more difficult recruitment environment requires even greater attention to achieving and maintaining such a balance. Well-planned knowledge management programmes can contribute to meeting such challenges. (See: *balanced scorecard* and *knowledge assets*).

### attrition

A decrease in the number of employees in an organization due to retirements, other terminations, or transfers to other organizations.

: In the nuclear industry attrition due to retirement is a particularly important issue because plants typically have stable workforces, all or most of whom joined during the commissioning phase, and thus they often have similar retirement dates.

### balanced scorecard

A business model used as a tool to measure organizational performance against both short and long-term goals.

*Comment*: This model is designed to focus attention on the factors that most help business strategists and so, alongside financial measures, offers means of measuring internal processes and employee learning. Some organizations in the nuclear industry use the 'balanced scorecard' model in setting and measuring knowledge management strategies.

### benchmarking

The practice of comparing features and performance of an organization, department or function with those of other organizations and standards.

*Comment*: The following axioms should be considered in benchmarking:

— What works well for a given organization in one situation may not work well in another organization under different circumstances;
— There are lessons to be learned from undesirable situations as well as from best practices — things that have been proven to work well and produce good results;
— Examining the practices of organizations with fundamentally different aims can produce surprisingly useful insight about another organization.

**best practice**

A process or methodology that has been shown to work well and produce good results and is, therefore, recommended as a model.

**capacity building**

The process of enhancing an organization's ability to achieve its goals and also implement knowledge management principles and practices.

**champion**

A person who proactively promotes something with the aim of persuading others of its benefits.

*Comment*: In the nuclear industry a champion for organizational change is often a senior line manager who regularly monitors the plans and progress in implementing change, and helps to overcome barriers to change.

**chief information officer (CIO)**

A senior position with strategic responsibility for information management and information technology.

**chief knowledge officer (CKO)**

A senior position with strategic responsibility for promoting and implementing knowledge management.

**coaching**

A relationship between more experienced individuals and less experienced individuals designed to enhance learning and performance of both individuals and teams, typically focused on the achievement of specified objectives within given time frames.

*Comment*: The role of a coach is to create a supportive environment that will develop the ability of those being coached to perform existing tasks better or new tasks. In the nuclear industry, coaching is a legitimate and effective teaching tool for situations like on-job training (OJT); however, it is to be avoided during the process of confirming acquired competences. For this reason, some utilities prohibit OJT instructors/coaches from also serving to evaluate the effectiveness of the learning by trainees on given tasks. Coaches may be from within or from outside an organization. (See also *mentoring* and *reverse coaching and mentoring*).

**codification**

The process of converting people's knowledge into a form to enable it to be communicated independently of those people.

*Comment*: The most common method of codification is writing things down and incorporating them into documents and databases. Other methods include pictures, sound and video recordings. In the nuclear industry codification has been particularly important in ensuring that the design basis for an NPP's safe operation is effectively maintained. (See also *knowledge harvesting*).

**collaboration**

A generic term to describe teamwork or group effort.

*Comment*: In knowledge management, collaboration is often used more specifically to describe close working relationships involving the sharing of knowledge. An example of collaboration in the nuclear industry is a cross-functional team.

**communities of practice**

Networks of people who work on similar processes or in similar disciplines, and who come together to develop and share their knowledge in that field for the benefit of both themselves and their organization(s).

*Comment*: Communities of practice may be created formally or informally, and they can interact online or in person. In a less-formal context, they are sometimes referred to as *Communities of interest*. An example in the nuclear industry is the Nuclear Energy Institute's Community of Practice.

**concept maps**

Tools for organizing and representing knowledge.

*Comment*: Concept maps include concepts, usually depicted in circles or boxes of some type, and relationships between concepts or propositions, indicated by a connecting line between two concepts.

**configuration management**

The process of identifying and documenting the characteristics of an organization's structures, systems and components (including computer systems and software), and of ensuring that changes to these characteristics are properly developed, assessed, approved, issued, implemented, verified, recorded and incorporated into the organization's documentation.

*Comment*: The IAEA-TECDOC-1335, 2003, *'Configuration management in nuclear power plants'* presents a basic approach to configuration management; it considers experience gained from discussions at meetings organized on the subject, and from organizations and utilities, which have successfully implemented partial or full configuration management programmes.

**content management**

A means of ensuring that computer-based information, such as the content of a website or a database, is relevant, up-to-date, accurate, easily accessible, or well organized, so that quality information can be delivered to the user.

*Comment*: Configuration management, as used in the nuclear industry, is an effective tool for the maintenance of content management.

**corporate memory**

The knowledge and understanding embedded in an organization's employees, processes and products or services, together with its traditions and values. Corporate memory can either assist or inhibit the organization's progress. Also termed *organizational memory*.

*Comment*: Corporate memory becomes a critical concern when there is sufficient migration of personnel from an organization as to cause a knowledge deficit. This phenomenon can be due to factors such as planned reductions in the workforce, accidents, illness, retirements, or — most commonly — personnel leaving due to dissatisfaction with immediate supervision. In these situations, the tremendous financial investment in an organization's personnel and their tacit knowledge becomes evident. In the nuclear industry corporate memory is particularly important in ensuring that the design basis for the NPP safe operation is effectively maintained. (See *knowledge*).

**critical knowledge**

The knowledge established in the context of a particular position that is deemed imperative for incumbents of said position to possess before being allowed to perform associated duties and tasks independently.

**data**

A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by people or by automatic means.

**database**

A collection of information organized in such a way that a computer program can quickly select desired pieces of data. Relational databases are organized by fields, records, and tables. A field is a single piece of information, a record is one complete set of fields, and a table is a collection of records. Storing content in fields rather than on static pages makes that content appropriate for dynamic delivery.

*Comment*: The International Nuclear Information System (INIS), maintained by the IAEA, is the world's leading information system on the peaceful uses of nuclear science and technology. This database indexes scientific literature published worldwide on the peaceful applications of nuclear science and technology focusing on technical data, references, and bibliographies from the world's biggest digital nuclear reference centres in fields of nuclear science and technology. Legal and social aspects associated with nuclear energy are included, as well as the economic and environmental aspects of all non-nuclear energy sources.

**data mining**

A technique for analysing data in databases and making new connections between the data in order to reveal trends and patterns.

**document**

A record of an event or knowledge, taken so, that the information will not be lost.

*Comment*: Documents are usually written, but they can also be made up of images or sound. Documents can be put into electronic or digital form and stored in a computer.

**document management**

Systems and processes for managing documents including the creation, editing, production, storage, indexing and disposal of documents. This often refers to electronic documents and uses specific document management software.

*Comment*: IAEA-TECDOC-1284, 2002, 'Information Technology Impact on Nuclear Power Plant documentation' addresses all aspects of documentation associated with various life-cycle phases of NPPs and the information technology (IT) that are relevant to the documentation process. It also provides a guide for planning, designing, and executing an IT documentation project. This report includes examples that demonstrate successful implementations at NPPs and also discusses issues related to the application of IT at NPPs and the trends for applications of IT at NPPs as well as the technology itself.

**e-learning**

An abbreviation of electronic learning. The use of electronic information systems (especially internet technologies) to deliver or receive learning and training.

*Comment*: A common application of e-learning in the nuclear industry is general employee refresher training. Due to the large number of trainees, the relatively high cost of e-learning can be justified, and the flexibility of e-learning is well suited to allowing the trainees to complete the training when they have the time available. Also, a 'test-out' feature can allow trainees who already understand the material to complete a pre-test, and if successful to avoid spending time on topics in which they are already competent.

**events**

Activities, occurrences, or incidents — planned or unplanned — that have significance to society, organizations or individuals.

*Comment*: In nuclear technology fields, events are typically both unplanned and undesirable. Some regulatory systems have categories for events based on their levels of severity, i.e. their potential for harmful results. Within the IAEA, and specifically in the context of the reporting and analysis of events, an event is any unintended occurrence, including operating error, equipment failure or other mishap, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.

*Note*: Within IAEA documentation, the terminology related to the reporting and analysis of events is not always consistent with the terminology used in safety standards, and great care should be taken to avoid confusion. In particular, the definition of 'event' as given above is identical in essence to the safety standards' definition of 'accident'. The difference derives from the fact that event reporting and analysis is concerned directly with the question of whether an event that could develop into an accident with significant consequences actually does so; terms such as accident are used only to describe the end result and, therefore, other terms, such as event, are needed to describe the earlier stages.

**exit interview**

A survey that is conducted with an employee who is about to leave an organization.

*Comment*: The information from each exit interview is used to provide feedback on why employees are leaving, what they liked about their employment and what areas of the organization need improvement. Exit interviews are used as part of *knowledge harvesting* to glean knowledge from the departing employee so that it is retained within the organization. (See *knowledge harvesting*).

**expert system**

A data processing system that provides for solving problems in an expert manner within a given field or application area, by drawing inferences with the aid of a knowledge base developed from human expertise. An expert system is a branch of artificial intelligence. (See *knowledge base*).

**extranet**

A computer network that links an organization with other specific organizations or persons. Extranets are accessible only to specified organizations or persons and are protected by passwords. (See also *intranet*).

**human assets**

The knowledge, skills and competences of the people in an organization. Human assets are a component of *intellectual assets*. *Comment*: The IAEA-TECDOC-1479, 2005, *'Human performance improvement in organizations: Potential application for the nuclear industry'* provides managers and specialists in nuclear facility operating organizations working in the area of human resource management with practical information that they can use to improve human performance in their organizations.

**information**

Data that has been organized within a context and translated into a form that has structure and meaning. (See also *knowledge*).

**information audit**

A method of reviewing and mapping information within an organization.

*Comment*: An information audit examines what information is needed, what information there currently is, where it is, in what forms, how it flows around the organization, where there are gaps and where there is duplication, how much it is costing, what its value is, how it is used etc. (See also *knowledge audit*).

**information management**

The management of an organization's information resources with the aim of improving the performance of the organization. Information management underpins knowledge management, as knowledge is derived from information.

**information technology (IT)**

The elements of computing, including software, servers, networks and desktop computing, which enable digital information to be created, stored, used and shared.

**institutional knowledge**

The collective knowledge of all the employees working in an organization or institution.

**intellectual capital**

The intellectual material, such as knowledge, information, intellectual property, experience, which can be put to use to create wealth.

*Comment*: In the nuclear industry, the large investment in intellectual capital is perhaps most visible by the high financial outlay required to get control room personnel authorized (licensed) and to maintain the knowledge base that warrants continuation of those individual operating permits. (See also *intellectual property* and *knowledge assets*).

**intellectual property**

Explicit knowledge assets that are protected by law. Intellectual property includes items such as patents, trademarks, copyrights, licenses etc. (See *knowledge* and *knowledge assets*).

**internalization**

The process of absorbing explicit knowledge and making it tacit. (See *knowledge).*

**intranet**

A computer network that functions similarly to the Internet, but the information and web pages are located on computers within an organization rather than being accessible to the general public. (See also *extranet*).

**know-how**

Skill or competence derived from knowledge and experience.

**knowledge**

A acquiring, understanding and interpreting of information. Knowledge is often used to refer to a body of facts and principles accumulated by humankind over the course of time. *Explicit knowledge* is knowledge that can be easily expressed in documents. *Implicit knowledge* and *tacit knowledge* represent knowledge or know-how that people carry in their heads.

*Comment*: Knowledge is distinct from information as knowledge is information that has a purpose or use. Data leads to information and information leads to knowledge. Knowledge confers a capacity for effective action.

Knowledge may be applied to such purposes as problem solving and learning, forming judgments and opinions; decision making, forecasting and strategic planning; generating feasible options for action and taking actions to achieve desired results. Knowledge also protects intellectual assets from decay, augments intelligence and provides increased flexibility.

*Explicit knowledge* is contained in documents, drawings, calculations, designs, databases, procedures and manuals. *Explicit knowledge* implies declared knowledge (i.e. knowledge that is conscious to the knowledge bearer). *Explicit knowledge* is why it is not a problem for the employee to tell about rules and obviously learned facts. Very often this knowledge is already written down in books. Examples that contain explicit knowledge include NPP documentation and databases such as a website, an operational manual, records or a report of research findings.

*Implicit knowledge* and *tacit knowledge* are held in a person’s mind and have typically not been captured or transferred in any form (if they had, they would then become *explicit knowledge*). Compared with *explicit knowledge*, such knowledge is more difficult to articulate or write down and so it tends to be shared between people through discussion, stories and personal interactions. It includes skills, experiences, insight, intuition and judgment.

*Implicit knowledge* is difficult to reveal, but it is still possible to be recorded. Usually knowledge bearers cannot recall this knowledge by themselves, because the information is too obvious to them. Some authorities draw a distinction between *tacit* and *implicit knowledge*, defining *tacit knowledge* as that which cannot be written down, and *implicit knowledge* as that which can be written down but has not been written down yet. In this context, *explicit knowledge* is defined as that which has already been written down.

*Tacit knowledge* has been called ‘what we know but don’t know we know’. It is the most difficult type of knowledge to recall and, thus, to transfer. Tacit knowledge includes knowledge about topics such as how to ride a bicycle or how to talk. These examples describe knowledge everybody just has. However, every individual possesses a lot of *tacit knowledge*. Employees, for example, tacitly know how they persuade other people, how to behave in different situations, or how to organize a meeting. Such knowledge cannot be completely explained, since it is wholly embodied in the individual, rooted in practice and experience, expressed through skilful execution, and transmitted by apprenticeship and training through watching and doing forms of learning.

Sometimes *tacit knowledge* is used as alternative terminology for *implicit knowledge;* however, technically, the two identify different categories of knowledge.

(See *information* and *critical knowledge*).

**knowledge assets**

Those parts of an organization's *intangible assets* that relate specifically to knowledge, such as *know-how*, *best practices*, and *intellectual property*. Knowledge assets are often divided into human (people, teams, networks and communities), structural (the codified knowledge that can be found in processes and procedures) and technological (the technologies that support knowledge sharing such as databases and intranets). (See *best practices, intellectual property*, and *know-how)*.

*Comment*: By understanding the knowledge assets an organization possesses, the organization can improve its ability to use them to best effect and also identify any gaps that may exist.

**knowledge audit**

A method of reviewing and mapping knowledge in an organization, including an analysis of its knowledge needs, resources, flows, gaps, users and uses.

*Comment*: A knowledge audit generally includes aspects of an *information audit* but is broader in its scope. (See *information audit*).

**knowledge base**

The fundamental body of *knowledge* available to an organization, including the knowledge in people's heads, supported by the organization's collections of information and data. (See *data*, *information* and *knowledge*).

*Comment*: An organization may also build subject-specific knowledge bases to collate information on key topics or processes. Knowledge base is also sometimes used to describe a *database* of information. The nuclear industry has a variety of knowledge bases; some are industry wide, such as the IAEA's Power Reactor Information System (PRIS) database and International Nuclear Information System (INIS) database. Knowledge bases of NPP operating organizations include plant procedure systems, system description documents and technical manuals.

**knowledge broker**

A person who facilitates the creation, sharing and use of knowledge within an organization.

*Comment*: Many organizations have created knowledge broker roles such as a 'Knowledge Co-coordinator'. 'Knowledge broker' is also sometimes used to describe a company or individual that operates commercially as a knowledge trader or provides knowledge-related services.

**knowledge capture**

A process of capturing the knowledge available within an organization and making it available.

*Comment*: More than ever before, organizations need to find ways to capture employee knowledge and best practices and ensure that they are shared and used throughout the workplace. To achieve this, organizations must uncover and address the gaps between their goals and their current knowledge-transfer practices. New tools and technologies must be supported with process and cultural changes and populated with high-quality structured content. (See *knowledge transfer*). A complete solution requires:

- effective architectures, techniques, and standards for organizing and presenting content effectively;
- new skills to help personnel understand what knowledge to capture, and how to document it, in order to maximize its usefulness to others;
- revised goals and expectations that make knowledge capture a high-priority in everyone's job;
- efficient systems and tools that centralize knowledge content and make it easy to store, access, and maintain.

**knowledge centre**

A place where knowledge is gathered and stored and can be accessed and used.

*Comment*: A knowledge centre may be a physical place such as a library, a virtual place (a knowledge portal), such as an interactive web-site or on-line discussion board, or a place where people gather, such as a café, an informal meeting room or a discussion area created to encourage knowledge sharing. (See *knowledge portal* and *virtual*).

**knowledge economy**

An economy in which knowledge plays a predominant part in the creation of wealth.

**knowledge flows**

The ways in which knowledge moves within, and into and out of, an organization.

**knowledge harvesting**

A set of methods for making implicit knowledge more explicit — incorporating people’s knowledge into documents, to enable it to be more easily shared with others. (See k*nowledge* and *codification*).

**knowledge loss risk assessment**

A process used to determine the potential business impact of the loss of critical knowledge from an organization.

*Comment*: This process is a part of organization’s overall strategy to address the challenges created by an ageing workforce. The process is designed to:

- Identify expert incumbents who possess critical knowledge and skills;
- Conduct a risk assessment based on two factors: time until retirement and position criticality;
- Determine the most appropriate method(s) for addressing potential knowledge loss through attrition;
- Establish knowledge retention plans that meet continuously changing business needs;
- Provide a process to review results and ensure knowledge retention plans are monitored and evaluated.

(See *attrition, critical knowledge, knowledge retention plan* and *position criticality*).

**knowledge management**

The integrated, systematic approach to identifying, managing and sharing an organization's knowledge, and enabling persons to create new knowledge collectively and thereby help achieve the objectives of that organization.

Knowledge management is defined, in this publication, as an integrated, systematic approach to identifying, acquiring, transforming, developing, disseminating, using, sharing, and preserving knowledge, relevant to achieving specified objectives.

*Note*: Knowledge management consists of three fundamental components: people, processes and technology. Knowledge management focuses on people and organizational culture to stimulate and nurture 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.

**knowledge management solution**

A solution to a knowledge management problem, or the use of knowledge management techniques to solve an organizational problem.

*Comment*: Examples of knowledge management solutions include upgrades of plant procedure systems to provide additional detail, mentoring assignments for employees soon to retire, and more structured on-job training programmes.

**knowledge management strategy**

A detailed plan outlining how an organization intends to implement knowledge management principles and practices in order to achieve organizational objectives.

*Comment*: There are many strategies used to preserve knowledge. Primarily, the activities to be deployed largely depend on the nature of knowledge: tacit knowledge requires greater efforts to preserve knowledge than explicit knowledge. While tacit knowledge can be preserved only by transferring it to successors or simply other people (a so-called personalization strategy), explicit knowledge benefits from the possibility of articulation or codification and being stored, with the help of advanced information and communication technologies. Preserving tacit knowledge is equal to transferring tacit knowledge to other employees or to engage in a knowledge transformation process that transforms tacit knowledge to explicit knowledge. Such endeavours are highly time-consuming.

Generally, two categories of knowledge preservation strategies (activities) can be discerned: personalization strategies (knowledge transfer) and codification strategies (knowledge articulation/elicitation). (See *codification* and *knowledge*).

**knowledge mapping**

A process to determine where knowledge assets are in an organization, and how knowledge flow*s* operate within the organization. Evaluating relationships between holders of knowledge will then illustrate the sources, flows, limitations, and losses of knowledge that can be expected to occur. (See *knowledge assets, knowledge flows,* and *concept maps)*.

**knowledge officer**

A role with responsibility for implementing knowledge management principles and practices. (See also *chief knowledge officer*).

**knowledge portal**

A comprehensive access structure to resources that are suitable to support the fundamental activities of knowledge management in a given knowledge domain to communicate, study and do research.

*Comment*: Knowledge portals typically provide a single, personalized interface point for accessing and consolidating information from disparate sources. Knowledge portals can be used to access knowledge repositories and communities of practice. Typical resources that should be accessible via a knowledge portal are information items about places of learning, opportunities for learning and research, experts, meeting opportunities, factual data and informative texts. (See *communities of practice* and *knowledge repositories*).

**knowledge preservation**

A process of maintaining an organizational system of knowledge and capabilities that preserves and stores perceptions, actions and experiences over time and secures the possibility of recall for the future.

*Comment*: The preservation of knowledge is an important building block within the knowledge management field. Organizations that intentionally manage their experiences for them to be available for the future have to master three basic processes of knowledge management:

- select, from the large number of organizational events, persons or experts and processes, only those that are worth preserving;
- store their experience in a suitable form;
- ensure the setting up and operation of the organizational memory.

**knowledge repository**

A place to store and from which to retrieve explicit knowledge.

*Comment*: An example of a low-technology knowledge repository is a set of file folders. A high-technology knowledge repository might be based on a database platform.

**knowledge retention plan**

A plan that identifies the critical knowledge and positions in an organization, and methods to be used for addressing potential knowledge loss through attrition, and the process that will ensure that the plan is continually updated to meet changing business needs. (See *attrition* and *critical knowledge*).

**knowledge transfer**

The transfer of knowledge in a broad array of settings: between individuals, groups of individuals, communities, organizations, industries, or even nations.

*Comment*: Several ‘levels of transfer’ can be distinguished, depending on complexity. At level I, the objects of transfer are data and materials (materials, components, intermediate and end products, etc.). Such knowledge transfer will not enable the recipient to recreate the sender’s knowledge. At level II the sender transfers documentation and blueprints and the necessary information to manufacture products based on documentation and blueprints. Documentation and blueprints correspond to the explicit knowledge of the original technology developer. At level III the recipient is able to reproduce the knowledge and change it, adapting it to different conditions. Such transfers have to be accompanied by elements of level I and II transfers for the recipient to fully understand the sender's knowledge. (See *knowledge*).

**knowledge worker**

An employee whose role relies on an ability to find and use knowledge.

**learning histories**

Explicit knowledge that has been developed from storytelling by individuals who are familiar with activities and events, in order to record their observations, perspectives, and interpretations for analysis and use by others in performance-improvement initiatives.

*Comment*: Such documenting processes typically involve small groups of people familiar with the topic and can be in formats varying from simple narratives to elaborate compilations. The development processes themselves have the potential of increasing involvement and trust, raising sensitive issues that otherwise might not be put forward, transferring knowledge beyond the immediate source environment, and building a body of management knowledge about what works and what does not work (and, in some cases, why). In the nuclear industry, developing learning histories can serve not only the above purposes but also enhance the enjoyment and effectiveness of training exercises that are designed to convey operating experience and lessons learned. (See *knowledge* and *storytelling*).

**learning organization**

An organization whose key personnel view its future success as being based on continuous learning and adaptive behaviour. The organization, therefore, becomes renowned for creating, acquiring, interpreting and retaining knowledge and then modifying its behaviour to reflect new knowledge and insights.

**lessons learned**

Concise descriptions of knowledge derived from experiences that can be communicated through mechanisms such as storytelling, debriefing etc., or summarized in databases. (See *database* and *storytelling*).

*Comment*: Such lessons often reflect on 'what was done right', 'what should be done differently', and 'how to improve the process and product to be more effective in the future'. In the nuclear industry, operating experience feedback is an example of an applied lessons learned programme.

**leverage**

The realization of the inherent value of an asset — physical or knowledge-based — beyond what is currently being realized. In short, to get more value out of it. (See *knowledge asset*).

**mentoring**

A relationship between a more experienced individual and a less experienced individual that exists in a one-on-one fashion, designed to enhance the menthe's understanding of, and ability to put into practice, knowledge and skills possessed by the mentor. Such relationships are usually established for extended periods of time and typically have general rather than specific objectives.

*Comment*: The role of a mentor is to transfer from the mentor to the menthe ideas and thought processes that are designed to foster critical thinking skills, self-confidence, and role maturity rather than to teach physical capabilities to perform specific tasks. In the nuclear industry, mentoring is often used to pair more senior personnel with junior personnel to assist the latter with professional and career development. As with coaches, mentors may be drawn from within or from outside an organization. (See also *coaching* and *reverse coaching and mentoring*).

**multi-skill assistance**

A process in which an individual or team arranges a meeting or a workshop in order to make use of the knowledge and experience of others before embarking on a project or activity.

*Comment*: In the nuclear industry some organizations have established multi-skilled teams for maintenance work, where each team has the collective skills needed to complete their assigned work. Often team members provide cross-training for other team members on simpler tasks in their discipline for team members to be individually assigned to a broader range of tasks. Also termed peer assistance.

**network**

(1) A connection of two or more institutions that enables them to share information resources.

(2) A wide variety of systems of interconnected components. Specific examples include:

- social networks, business networks and entrepreneurial networks,
- computer networks, which transfer information between computers. (Specific configurations include star networks and grid networks.) The Internet is a large-scale computer network. A web-site and the entire World Wide Web are also networks of web-pages, a link web.

*Comment*: The Asian Network for Education in Nuclear Technology (ANENT) supported by the IAEA is a new partnership for co-operation in human resource development and research in nuclear technology as a key strategy for capacity building, nuclear infrastructure development and better use of available information resources. The ANENT was established in February 2004, to promote, manage and preserve nuclear knowledge; to ensure the continued availability of talented and qualified manpower in the nuclear field in the Asian region; and to enhance the quality of the human resources for the sustainability of nuclear technology. Universities, research centres, government agencies and other institutions involved in nuclear education and training in the region, are accepted as participating members of ANENT and international or regional networks as collaborating members. Currently there are 28 participating institutions from 12 countries (Australia, China, India, Indonesia, Malaysia, Mongolia, Pakistan, Republic of Korea, Sri Lanka, Thailand, Philippines and Vietnam) and six networks as collaborating members. (See also *extranet* and *intranet*).

**nuclear knowledge portal**

A knowledge portal that focuses on resources in the domain of nuclear knowledge. (See *knowledge portal*).

**organizational culture**

A mixture of an organization’s traditions, values, attitudes and behaviours. In short, ‘the way things are done around here’. Different organizations can have very different cultures.

*Comment*: In knowledge management, an organization’s culture is extremely important - if it is not based on qualities such as trust and opennes
are unlikely to succeed. In the nuclear industry some organizations use organizational culture

surveys, which help managers to know the extent to which the organizational climate supports the sharing of knowledge.

**organizational learning**

The ability of an organization to gain knowledge from experience through experimentation, observation, analysis and a willingness to examine both successes and failures, and to then use that knowledge to do things differently.

*Comment*: While organizational learning cannot take place without individual learning, individual learning does not necessarily produce organizational learning. Organizational learning occurs when an organization becomes collectively more knowledgeable and skilful in pursuing a set of goals.

**organizational memory**

An alternative term for corporate memory. (See *corporate memory*).

**organizational silo**

An individual group within an organization, such as a department or unit.

*Comment*: 'Silo' is often used to suggest that such groups tend to be inward-looking and do not take account of what other similar groups are doing or how their work affects other such groups.

**peer assistance**

An alternative term for multi-skill assistance. (See *multi-skill assistance*).

**portal**

A special web-page that organizes access to all of the online resources relating to a topic, similar to providing a 'one-stop shop'.

**position criticality**

The importance of a particular position relative to all positions being considered in an assessment of available qualified staff to perform the functions necessary to assure safe, reliable, cost effective operation.

*Comment*: In the operation of a nuclear power plant, it is obvious that the positions occupied by those persons who operate the control room — and, thus, the nuclear reactor controls — are more critical those that of nuclear engineers whose work will be checked and re-checked by peers and responsible managers before being accepted for action. Both roles are important to power plant operation; however, the former can influence the reactor's operation directly and immediately, whereas the latter's impact is indirect and subject to intermediate assurances of correctness.

**post-job briefing**

An alternative term for *after-action review*. (See *after-action review*).

**pre-job briefing**

A process that involves conducting a structured and facilitated discussion before a task or project is performed to explain what should happen. (See also *after-action review*).

**records management**

Processes relating to the generation, receipt, processing, storage, retrieval, distribution, usage and retirement of an organization's records.

*Comment*: A means of helping an organization to make sure it is creating and maintaining an adequate documentary record of its functions, policies, decisions, procedures, and essential transactions, whether in paper, film, electronic record, or some other medium. Records management thus helps the organization to decide which records to keep and which to destroy and how best to organize them all. (See also *document management*).

**reverse coaching and mentoring**

A relationship by which senior individuals in an organization can learn from junior personnel whose experiences, skills and thought perspectives differ from their own.

*Comment*: Even where formal 'reverse relationships' are not established within an organization, this is a critical strategic consideration as the demographic profiles of the workforce and social dynamics change from traditional patterns to ones that tend to create generation gaps. In the nuclear industry, such relationships hold the potential to improve new employees' feelings of contributing and being valued for what they bring to the organization; to enhance diversity initiatives; to facilitate the learning by more senior personnel of new skills from less senior personnel (such as computer utilization and understanding the jargon of younger employees and their peer groups).

**root cause analysis (RCA)**

A generic problem-solving methodology employed to determine the fundamental causes (root causes) of events that have an impact on safety, health, environment, quality, reliability, or production. Such systematic investigations help identify 'what, how, and why' something happened so that recurrence might be prevented.

*Comment*: Events rarely have a single root cause. Thus, it is critical that a root cause analysis (RCA) team does not 'jump to judgment' and that a sufficiently thorough investigation is made to be reasonably certain that all underlying causes have been identified and that relevant, but non-causal factors, have been filtered out during the RCA process.

**search engine**

A mechanism that identifies which items, out of a given collection, conform to a given query string.

**self-assessment**

The process by which an organization assesses its own KM maturity by considering its present processes/systems and its future KM needs.

*Comment:* The IAEA has developed a self-assessment tool to facilitate this process.

**socialization**

The process of sharing tacit knowledge by bringing people together to facilitate observation, discussion, imitation, and practice.

*Comment*: One way of implementing socialization is by storytelling. However, the transfer of tacit knowledge through socialization, without the creation of explicit knowledge in the process, is a rather limited form of knowledge creation. Because of this, the nuclear industry has structured training programmes to achieve not just tacit to tacit knowledge creation, but also explicit to explicit, tacit to explicit, and explicit to tacit knowledge transfer. (See *storytelling* and *knowledge*).

**social network**

A way of describing systems composed of multiple elements that are related in some way. Each element, or node, may or may not have a relationship with the other nodes. In an organizational context ‘nodes’ are people and ‘relationships’ might be a subject (e.g. ‘customer needs’) that the ‘nodes’ discuss, or might be a physical activity (e.g. ‘are in contact with as part of normal work’). Often, the ‘relationship’ between two people is further described by a frequency, indicating how often the relationship is active.

*Comment:* Effective knowledge sharing is a key to success in most organizations. Social network analysis can document how knowledge is currently shared within the organization and help identify simple initiatives that often lead to a dramatic increase in knowledge sharing. Social network analysis can also help managers to understand how knowledge enters and flows within an organization. It can also identify pools of knowledge within the organization and can document how accessible it is to others. (See *knowledge*).

**storytelling**

The practice of relating personal recollections, impressions, perspectives, observations, and interpretations, typically with the aim of conveying a particular series of events that collectively convey a message that is of use to the listeners.

*Comment*: Civilization has spread and advanced through the gathering of people to orally share perspectives and interpretations of events in their lives and in the lives of others. From such activities, ‘stories’ have emerged that have been transferred beyond the original gathering in both oral and written forms. This practice is used in business and industry to transmit tacit knowledge orally and to develop learning histories that can then be utilized extensively for a variety of purposes. (See *learning histories* and *knowledge*).

**succession planning**

A methodology for identifying and developing employees to ensure that key organizational positions can be filled with qualified internal candidates, in advance of actual need, and to assist in managing diversity and workforce planning.

*Comment*: When necessary, candidates may be recruited externally. In the nuclear industry succession planning is often used for management and senior technical positions.

**taxonomy**

A hierarchical structure in which a body of information or knowledge is categorized, allowing an understanding of how that body of knowledge can be broken down into parts, and how its various parts relate to each other. Taxonomies are used to organize information in systems, thereby helping users to find it.

**thesaurus**

A hierarchical arrangement of related words and phrases often displayed in systematized lists of synonyms.

**undocumented knowledge**

Knowledge in an organization that has not been documented in such a way that it is accessible to those who may need it.

*Comment*: Undocumented knowledge can be tacit knowledge which may be very difficult to elicit, such as clues that an experienced field operator uses to anticipate problems at an NPP, or knowledge that can easily be externalized, such as an engineer's informal calculation of the basis for the minimum required feed water flow that has never been included in the appropriate plant system description document. (See *knowledge*).

**virtual**

Something that exists or is brought together via electronic networks, rather than existing in a single physical place. (See also *portal* and *virtual team*).

**virtual team**

A team whose members are not located together but who utilize electronic networks for communication, collaboration and work processes.

**workforce planning**

The process that identifies or anticipates vacant positions and the required staffing levels and skills to ensure the retention of institutional knowledge and critical skills and competences to support future business strategies.

*Comment*: This information addresses potential gaps between current and projected workforce needs. It takes into account diversity and labour costs and so becomes a part of the staffing plan in an organization's business plan. It includes attrition data, planned retirements, vacant positions, development plans, succession plans, and current workforce requirements. (See *attrition*, *institutional knowledge* and *succession planning*).

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