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Management System Types for Nuclear Organizations

A Comparative Overview

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Abstract:

This paper explores the knowledge-based, rule-based and process-based management systems, and presents the differences between them. Different types of management systems provide different plant-specific results. As organizations continually seek to maintain and improve their performance; transitions are being explored further, to look at the potential of extending the traditional organizational management systems to include more of a holistic and integrated performance-based model approach. It is widely accepted in the nuclear industry that a robust and interlinked model can ensure, a strong safety culture, high performance and overall nuclear power plant (NPP) efficiency. This is why other NPPs around the globe are trending towards the development of an Integrated Management System (IMS).

Introduction:

Nuclear is unique, but integrated management systems are not. They can be defined by many different names with popular references such as: operating model, integrated management model, business model, corporate strategy or organizational model. Each system is subtly different but provides a similar objective; that is to define how the organization operates.

Three decades ago the International Atomic Energy Agency (IAEA) began advocacy of the Integrated Management System and revised their Safety Standard on quality to GS-R-3 that is still in use today. Their intention was to bring total quality out of a silo-style environment that contained random unconnected documentation, to provide greater breadth across organizations. The IMS scope has continued to evolve ever since.

This paper is structured around compiling a clear, broad understanding and purpose of knowledge-based, rule-based and process-based management systems to aid NPPs in developing a model that is best suited to their organization.

Knowledge-based Management System:

Knowledge-based management systems make up an essential part of the IMS. They are built via a social and collaborative process with high human interaction by knowledge subject-matter-experts in building a knowledge-based system of acquisition, transfer, creation, retention, and utilization. IAEA theorize that they are comprised of three key components:

1. **Individual:** To use contributor knowledge and culture used to solve complex problems.
2. **Process:** Methods to find, create, capture and share knowledge.
3. **Technology:** ICT infrastructure to store and manage to make knowledge assessable.

The UAE nuclear regulator, Federal Authority of Nuclear Regulation (FANR), does not specify the type of management system required by regulation, leaving it to the organization to identify the best suited type to fit their needs. It is specified in Regulation 01, that 'knowledge be managed as a resource' (article 9.1) and Suitably Qualified Experienced Personal (SQEP) need to be employed to administer the system.

The World Association of Nuclear Operators (WANO) also define knowledge as an essential requirement in their recommended Performance Objectives and Criteria (PO&C). Knowledge is quantified specifically through the expectation that skilled nuclear workers have the requisite knowledge to perform their work safely and reliably. WANO also equates knowledge as lessons learned throughout the life of the plant, also recommended within various PO&Cs.

Knowledge-based systems can provide a strong foundation of disseminated information and the beginning of a framework for business rules.

Korean Hydro-electric Nuclear Power (KHNP) use a knowledge-basis for corporate and plant operations. This is evident through their procedures; that are less detailed and more open to interpretation than in other nuclear power plants. This management system works for KHNP as they utilize the implicit and tacit knowledge of their experienced operators to understand and safely follow procedures.

Rule-based Management System:

Rule-based management systems are used to: define, deploy, execute, monitor and maintain the variety and complexity of decision logic that is used by operational systems within an organization or enterprise. They attempt to minimize or completely remove the need for human interaction. It relies on known facts and process steps and indirectly specifies a mathematical model. Components of rule-based systems are also referred to as

procedures, requirements, and conditional statements that are used to determine tactical actions.

Rule-based logic lends itself to computer applications and programming steps, where precise process automation is possible. As such they are more suited to solving problems for which all knowledge in the problem area can be written in the form of '*if-then*' rules. They provide the basis for *expert systems,* where the knowledge of an expert emulates the decision-making ability of a human. Advanced rule-based systems automatically store and manipulate knowledge to interpret information in a useful way. This information can be automated and can ultimately become the decision-making foundation for Artificial Intelligence (AI).

They are fairly simplistic in nature. However if there are too many rules, the system can become difficult to maintain and as a result, performance can be compromised. One nuclear organization that has used its knowledge to build a rule-based system is Exelon. This is evident through their standardized Nuclear Management Model (NMM) which is offered commercially, espouses high safety performance and capability factors. The Exelon NMM provides a comprehensive set of documented rules that is suitable to operate several different NPPs, all however built initially on knowledge.

Process-based Management System:

For decades, utilities focused on traditional quality systems such as, International Organization for Standardization (ISO), Occupational Health and Safety Management Systems (OHSAS), Total Quality Management (TQM) and the IAEA 50-C-Q and Nuclear Quality Assurance (NQA-1) standards to run their nuclear operations. From the mid-1990s, this focus began to change and evolve into a process-based management system. This system demands commitment from senior leadership and requires the organization to identify the processes needed to achieve organization goals.

It is *systemic* in nature, encompassing all aspects of how the people, within the organization, accomplish work and communicate with stakeholders. It is also *systematic* in that every process consists of a logical sequence of activities with well-defined requirements, inputs, interfaces, outcomes and responsibilities.

They are typically structured with top level process model or framework depicting the organization and its operations. Under this frame resides three levels:

1. High level documents defining an overview of how the organization and its framework will meet its objectives.
2. Documents consisting of the core, performance improvement and supporting processes to be implemented.
3. Detailed procedures, instructions and guidance that enable the processes to be carried out.

It is intended for the operators of nuclear facilities to implement IAEA GS-R-3. IAEA is a strong advocate of the process-based management system and as such, their Safety Standard GS-R-3 is heavily based on the same principles. FANR has also adopted this approach and has developed their Regulation 01 on Management Systems with the same ideology.

Process-based management systems enable a high level of process quality and performance assistance by linking the management system to business process-tools such as SAP.

Over two years the *Kernkraftwerk Leibstadt* (KKL) NPP in Switzerland built its management system using GS-R-3. They claim that when integrated with an ICT platform, it enabled users of all levels to quickly access information and provide rapid responses to regulator questions.

Link to Performance:

Process based management systems are an important enabler of long-term organizational performance and is particularly important in technology intensive industries such as the nuclear industry.

It has an overall greater organizational performance, but must be aligned and optimized to meet the knowledge requirements of business processes. As shown in Fig.1, the ultimate quality of the IMS is enabled by quality processes that in turn enable decisions, then actions.

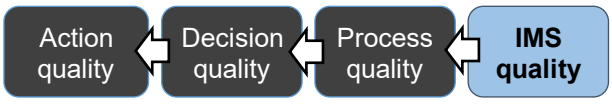

Figure 1: Enablers of IMS quality

This performance paradigm is applicable to all types of management systems whether it be a knowledge, rule or process-based system.

Advantages and Disadvantages:

	Advantages	Disadvantages
Knowledge-based	• Systems are foundationally strong by taking advantage of highly-skilled knowledge experts • Provides the foundation for all intelligent systems • Quickly adaptable to beyond-design problems by human expert involvement • Evolves and improves more rapidly with the addition of continuous learning and team-based engagement	• Can be difficult to obtain complete knowledge held by limited highly valued staff who are in constant demand by the organization • Heavily dependent on the implicit and tacit experience of the operator • Knowledge is subjective, open to interpretation and differing opinions • Needs constant active involvement from stakeholders who contribute to and benefit from using knowledge
Rule-based	• The critical information is robust, explicit rather than implicit or tacit • Improved efficiency of processes through better decision automation • Rules minimize subjectivity and can provide clear direction setting and the attainment of goals • Enables more objective decision-making	• Extensive and precise subject matter expertise required • Long development cycle due to rule development and integration with existing systems • Can't cover all unknowns or issues not considered • Highly dependent on knowledge to create and improve the system
Process-based	• Intrinsic link to quality • Underpins a safety culture specific to the nuclear industry • Provides a logical framework for nuclear operations at all level of the organization • Easier integration with industry standards from IAEA, ISO, EFQM, TQM and similar quality systems	• Requires individuals, processes and technology to work seamlessly together to function • For processes to be effective they must be linked to outcomes to be measured • Tends to provide only incremental innovation as users become locked into existing processes

Conclusion:

An effective management system can enhance an organization's capability to assimilate, create and exploit knowledge. It is too simplistic to suggest that for an organization to be successful, they should seek one type of management system. More accurately, there are many different successful *approaches* that share the levels and characteristics from any or all of the systems mentioned herein.

Regardless of the goal, all development approaches begin with knowledge, as does all intelligence. Using a knowledge-based approach, processes are defined and rules are established. Once in place, in a cyclical manner, knowledge once again is used to for continuous improvement of the management system and its components as shown in Fig.3.

Figure 3: Levels of the Nawah

The real value for organizational management systems comes not in the selected type but from the different weighting applied to each approach.

As nuclear organizations move forward with building and implementing hybrid management systems, they must take on the behavior of sharing. The objective remains the same; to make the organization's implicit and tacit knowledge in core competencies areas, explicit and in a form all staff can learn from.

Acronyms:

EFQM: European Foundation for Quality Management
FANR: Federal Association for Nuclear Regulation
GS-R-3: General Safety Requirement
IAEA: International Atomic Energy Association
ICT: Information and Communications Technology
IMS: Integrated Management System
ISO: International Organization for Standardization
KHNP: Korean Hydro-electric Nuclear Power
KKL: Kernkraftwerk Leibstadt (NPP)
NPP: Nuclear Power Plant

NMM: Nuclear Management Model
OHSAS: Occupational Health and Safety Management Systems
PO&C: Performance Objectives and Criteria
SQEP: Significantly Qualified Experienced Personal
TQM: Total Quality Management
UAE: United Arab Emirates
WANO: World Association of Nuclear Operators

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