An Integrated Performance Based Management System for Nuclear Organizations and its Compliance with National and International Standards

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1. Introduction

Quality assurance and quality in general has evolved over the years. The nuclear industry has always maintained a strong focus on its quality system starting from its stringent industry standards in the 60’s to a more structured and consensus-based QC and QA standards in the 80’s and 90’s. The focus of the earlier development of QC/QA based quality programs were on the quality and safety of individual products and items. The quality assurance based programs in the 80’s and early 90’s achieved the product quality, reliability and safety through a system approach that assured the quality of all products and items. The quality management approach in late 90’s further strengthened this focus on the quality system aspects to manage the safety and quality of products, services and processes. The recent move to an integrated approach to business operations and management is elevating the quality to the next level (Figure 1).

![Safety Standards on Management Systems](image)

Although the paramount focus of nuclear industry’s management system must remain on nuclear safety, environment, reliability and quality, there is general recognition that it must address other critical processes and operations that are essential for its performance and success as a business.

The Management System approach to quality management requires that all key aspects for the successful operations of the nuclear business must be considered and managed to achieve its established mandate and objectives. The current global environment and competitive leverage for survival requires that the management system must achieve the required business performance and results to meet the expectations of all its key stakeholders.

The International Atomic Energy Agency (IAEA) is taking a lead role in the direction of integrating all elements of managing nuclear facilities and activities. IAEA wants to ensure that all inter-related aspects
such as economic, health and safety, security, quality assurance and environment are not considered separately to nuclear safety but rather a single integrated management system that covers them all. IAEA is developing a new standard on Management System Requirements (GS-R-3) that will cover all these aspects as shown in Figure 2. This new IAEA standard is expected to be published in 2006 and will supersede the current set of IAEA Code and Safety Guides on Quality 50-C/SG-Q.

**Integrated Management Systems**

The Integrated Performance Based Management System (IPBMS) as described in this paper provides an approach to meet these objectives. It integrates all technical, operational and commercial processes of the organization including regulatory, technology, health and safety, environment, human resources, finance, marketing, etc. The IPBMS goes beyond the compliance model and it focuses on the performance and end results along with the inter-related processes and the system aspects. The IPBMS must assure all the stakeholders that their established objectives and goals are being addressed and measurements are in place to monitor progress and end results. The IPBMS is a natural evolution for nuclear organizations that have successfully mastered the compliance-based management system. The system must remain flexible and evolve to further enhance safety and performance as needed.

The paper provides an overview of the IPBMS model and how it can be applied in a large organization with a diverse range of nuclear business covering nuclear products and services from R&D support, nuclear services, design and engineering to reactor sales, construction & project management. It describes the key elements of the performance-based system and covers some of the monitoring and measurement aspects to verify business performance against established goals and objectives.

Examples are provided on its application and also how some of its elements and principles are adapted at Atomic Energy of Canada Limited (AECL). Based on its nuclear quality management system, AECL has obtained certification to ISO 9001 standards in a relatively short period. AECL has also obtained ISO 14001 certification for its nuclear licensed facilities & operations. AECL is a full service supplier of nuclear projects, plant life management, and refurbishments. AECL is the designer and developer of the CANDU pressurized heavy water reactor and manages construction of nuclear plants and facilities worldwide with international partners.
2. **Key Attributes of an Integrated Performance Based Management System**

A performance-based system integrates the traditional compliance-based aspects (e.g. regulatory, QA standards requirements) with all other aspects that are key for successful business performance. The integrated system covers all aspects of the business and its performance targets. It recognizes that:

- An effective management system must include all sub-systems including business processes, nuclear safety & health, technical work production, finance & revenue generation, administrative and support services.
- These sub-systems must be given adequate coverage and emphasis in their definitions, implementation, and maintenance in order to assure the commercial success without compromising safety & quality.
- Compliance to QA and regulatory requirements including applicable standards must be a paramount consideration and be clearly demonstrated.
- The system must provide flexibility to manage the changing market demands and environment. The system should also be easily adaptable to a diverse nuclear arena covering nuclear R&D, engineering services, design, manufacturing, construction and operation of nuclear facilities including research and power reactors.
- It must respond and adapt quickly to organizational changes.
- The system must be user-friendly and easy to apply for a wide variety of nuclear activities.
- It should provide clearly defined performance measures and indices to assess business performance at various levels.
3. Organizational Responsibilities for Management System

Generally, a large full service nuclear corporation or utility has several departments, sites and business units. A combination of functional, project and business units’ set-up becomes essential for its fiscal management and to manage its limited resources and expertise to compete in the current market environment.

In a performance based management system, irrespective of the set-up, the line managers and staff take direct and visible ownership of the system and its key processes needed to control and perform the work to desired performance objectives. This means that everyone is responsible and accountable for their work and their performance for satisfying customer, regulatory and business requirements of their products and services. The responsible line organization takes full responsibility for the development and effective implementation of its management system.

The shift in moving from a compliance-based to a performance-based Management System approach is illustrated in Figure 3. This is the view taken by the International Atomic Energy Agency (IAEA) also in defining the shift of responsibility for quality and quality assurance (Ref.01)

![Figure 3 - Shift to a Performance–based Management System](image)

The system implementation is monitored by the organization and steps are taken to make changes as needed to align it with their needs and performance targets. The central corporate performance management or quality office with a small core group of experts and system specialists develops the corporate standards and system documentation that supports the line organization in their adaptation of the system and its implementation. They also ensure that a consistent set of processes is used across the company to manage key activities such as design, engineering, etc.

Figure 4 provides a brief overview of the IPBMS responsibilities and how the corporate and local system including QA related functions responsibilities are executed. The system and QA specialists are assigned to the line organizations as needed based on the size, complexity and business activities of the unit.
The key principles for a performance-based management system for a large organization are:

- Central responsibility for the corporation to set its mandate, vision, values, policies and standards must rest with the corporate management. The overall standards, methodology and implementation strategy must be clearly defined and accepted across the organization.
- Detailed responsibility and accountability for the adaptation and implementation of the system must rest with the local organization and management. The responsibility for the performance, safety, customer requirements and quality of products and services must rest with those producing and delivering them.
- Responsibility for self-assessments and compliance review with the system requirements is done to the maximum extent possible at the local level. The Corporate review should be limited to the corporate standards and system documentation based on the feedback from the local organizations.
- Responsibility for independent compliance review and assessments must be kept separate from the line responsibilities engaged in work performance and verification activities.
- The continual improvement to the system and its implementation must be done at all levels in an integrated manner.

The corporate group can also maintain an independent oversight function to monitor and verify system implementation.
4. IPBMS Model and Documentation Structure

The IPBMS model is based on the proven Deming concepts of Plan Do Check and Act (PDCA).

As shown in Figure 5, the Management System covering all business concepts can be easily modelled around the PDCA concepts as described in ISO 9001:2000, Quality Management System Standard. The Figure shows how this can be applied for a large nuclear organization.

![Figure 5 – Management System Cycle](image)

The performance-based system share some of the similar elements as for the compliance based system but goes further to address other critical areas also. Some of the key elements of the performance-based system are:

- Mission/Values/Policies
- Goals/Objectives
- Organizational Roles, Responsibilities and Accountabilities
- Work Planning and Controls
- Personnel Capabilities, Competence and Performance
- Control of Processes, Products and Equipment
- Communication
- Verification
- Configuration Management
- Non-Conformance
- Corrective and Preventive Actions
- Records and Document Control
- Rewards and Recognition
- Performance Measures, Success Factors and Barriers
- Sharing of Experience and Learning
- Assessments
- Continuous Improvements

The structure of the documentation describing the performance based management system is designed to meet the following objectives:

- Facilitate the definition, documentation and implementation of an integrated management system across the company;
- Streamline the process for developing and documenting the management system over a defined hierarchy of manuals and procedures;
- Isolate documents describing work processes as much as possible from organizational changes;
- Limit the description of the company organizational structure to one family of manuals;
• Define and document all processes required to manage a successful company, including business, technical, regulatory, health and safety, and quality assurance processes.
• Allow the selection and controlled modification, as necessary, of the appropriate processes to deliver a specific product or service at minimum cost;
• Facilitate showing compliance with national and international standards.

The model for establishing the Management System documentation hierarchy for a large nuclear organization with a diverse business range of nuclear products and services as discussed above is provided in Figure 6.

![Diagram of Management System Documentation](image)

**Figure 6 – Management System Documentation**

The key documents for the IPBMS model are:

- **Corporate System Management Manual (s):** These cover the organization’s mandate, vision, values, policies, organizational details at the senior level, and the governance model including goals and objectives. It also covers all key business processes including business planning, customer and stakeholders feedback, performance metrics, rewards, and risk management. The business processes cover all major activities of the organization including the cross-functional interfaces, process owners, performance measures and drivers. The additional Management Manuals at the local levels can be developed as needed to supplement the Corporate System Management Manual with additional organizational details and other specific areas and performance aspects of interest at the local levels. These management manuals do not discuss the detailed compliance aspects with the technical, environment and quality assurance standards and regulatory requirements.

- **Corporate Compliance Program Manuals:** These are a set of manuals that address the Environment, Health and Safety, QA and other compliance aspects to the technical and applicable regulatory requirements, standards, jurisdictional laws and regulations. A number of generic manuals are produced covering the various life cycle activities such as R&D, Design & Engineering, Procurement, Construction, etc. to provide enough flexibility to the line organization for selection out of this suite of manuals to match with their specific business needs, customer and contractual requirements. These manuals are maintained separately, reviewed and updated at regular intervals to maintain compliance with changes in standards, regulations and market environment. These manuals generally do not cover the organizational details.

- **Procedures:** These support both the Management and Compliance Manuals: The procedures provide further details on how the requirements of the manuals and applicable standards, performance measures and regulations are complied with. The procedures are written in a generic format avoiding specific relationships and linkages with the organizational details.

- **Compliance Matrix Table:** Each manual has a compliance table, of the type shown in Table 1, indicating how the clauses of each applicable Standard (IAEA, ISO, CSA, ASME, US NRC CFR 50 App. B, NQA-01 etc.) and Performance Criteria, etc. are satisfied in the manuals and procedures.
Table 1 – Compliance Matrix

- **Management Plans**: These Plans are generated for projects and jobs as needed to meet the customer, regulatory and contractual requirements including the international standards (IAEA, ISO, etc.), local jurisdictional requirements and specific performance measures. The Plans are generated from the existing suite of corporate Management System and Compliance Program Manuals. The procedures are selected and adapted as needed to meet specific scope, business and performance objectives. Additional processes and procedures are developed to meet business needs. These Plans cover the detailed responsibilities and accountabilities needed to perform the job or project. These Plans are submitted for the customer and regulatory approvals as needed.

5. **Examples of IPBMS Implementation**

Consider that a customer wants the nuclear organization to provide the design of a nuclear power plant. The line organization will select the applicable aspects of the Management System Manual, Design Compliance Program Manual & procedures to conduct their work as noted in Figure-6. Additional supplementary work instructions and organizational details will be covered in the job specific Management Plan as needed.

However, if the nuclear organization gets a turn-key build and operate contract for a nuclear power plant, this will require the responsible line manager / project manager to select the Management Manual along with a series of life cycle Compliance Program Manuals to manage the project (Figure 6). Again additional supplementary instructions, organizational details, customer and regulatory interfaces will be covered in the project specific Management Plan with clear reference to the applicable corporate management system documentation as applicable.

The complex Plans with a broader scope and more stringent customer and regulatory interfaces have several levels of reviews to ensure that all business and compliance requirements are met. With this combination of the Management System and Compliance Program Manuals, the performance measurement and indices both at the corporate and local levels are embedded into each specific Management Plan developed to execute a job or a project.

6. **Performance Metrics**

Clearly, a performance-based system relies heavily on measurement to guide decisions and behaviour. Metrics need to provide:

- Feedback on progress against plan,
- Feedback on strategy implementation,
- Direction on behaviour.

Each of these is briefly discussed below.

Metrics on progress against plan typically involve markers or milestones for specific achievements as well as the standard financial results tracked by all organizations. These measures are somewhat retrospective, in that they document what happened but do not necessarily provide a predictor for future success.
Metrics on strategy implementation are intended to measure progress on aspects identified in strategic planning as important for future well-being and growth of the organization. Thus, they encompass specific improvement initiatives (e.g. customer focused initiatives such as quality improvement) and generic performance improvement initiatives such as training, employee well-being, etc.

Generally, there are few separate metrics directing behaviour. Instead, this aspect is an important consideration in deriving all specific metrics and is thus inherent in the both previous categories, although more prevalent on the strategic side.

The Balanced Scorecard of Kaplan and Norton (Ref.02) provides a framework for such metrics with four perspectives:
1. Financial
2. Customer
3. Internal-business process
4. Learning and growth.

One can think of these four perspectives as moving from the retrospective mode (1. financial) progressively to the predictive mode (4. learning and growth).

7. AECL approach to its Management System

AECL has adapted a number of elements of the IPBMS model in its Quality Management System (QMS), as noted in Figure 7.

The top-level management manual called AECL Management Manual (AMM) covers:
- An overview of the corporation and its mandate and vision, including its values, principles and policies that guide the Corporation’s conduct;
- A description of the organizational structure and the mandate of the various organizational units;
- An overview of business processes management, compliance management and assessments and reviews at AECL; and
- A listing of, and management responsibility for, products and services provided to external customers, supporting and evolving technologies, business and strategic initiatives, business processes, requirements upon AECL, and sites, facilities and offices that are managed by AECL.

In addition to the AMM, AECL has a set of QA Manuals under the Overall QA Manual (OQAM) covering the various nuclear life cycle programs (R&D, Design, Procurement, Software, etc.) and other Program manuals (Environmental Protection, Radiation Protection, Emergency Preparedness, etc.). AECL manages its projects and jobs both within Canada and worldwide by a set of job and project specific QA Manual & Plans. All such Q/QA documents have the compliance matrices that clearly demonstrate as to how the requirements of the applicable QA standard is complied with. AECL has effectively used this
approach over the last few years to considerably reduce proliferation of QA documentation and to help the organization move towards a broader management system, performance and customer focused approach rather than a compliance focused approach only.

AECL has a comprehensive self-assessment and internal audit program to verify the system implementation and its effectiveness. The Audit processes are now moving towards risk informed and performance-based audits and do include Horizontal and Vertical Slice Reviews. The Horizontal review can cover a specific process or function across the corporation. The Vertical Slice Review conducted during the various life cycle activities is an independent review to assess work performance to ensure that as-built and as-installed system and components meet the defined configuration and documented requirements. AECL also has a robust Self-Assessment process considered as the first line of defence in promptly resolving the issues, and in identifying areas for improvements.

On the business performance side, AECL uses a Balanced Scorecard type of approach. Due to the nature of its business, it places particular emphasis on community relations, safety and regulatory compliance. Included in these metrics are customer satisfaction measures and quality measures. As part of the quality measures AECL has established a quality index methodology to monitor its quality performance.

Since the formalization of the quality index is relatively recent, the experience base is small. As such, these measures have not yet reached the full potential and will be evolving as we develop experience with it. However, AECL has already seen the benefit of collecting such metrics as they provide a framework for discussion on improvement areas, both in performance and in the metrics themselves.

Corporate measures cannot capture all of the elements important in the different business areas of AECL. Thus, they do not replace the importance of individual units deriving their own objectives and metrics. Units are encouraged to be consistent with the corporate metrics but to add and modify them for their own specific requirements. This provides a healthy interface to learn from each other, improving the individual unit metrics as well as the corporate metrics. This interaction has already provided us insight on means for improvement.

8. Harmonization and Accreditation to National and International Standards

The global market environment, deregulation, competition and trade agreements offer considerable opportunities for nuclear organizations to enter into partnership and collaborative agreements. Such collaboration may lead to sharing of equipment, data, technologies and resources in order to manage joint projects and programs across the world. This requires such organizations to align and harmonize their work practices and management systems with the widely accepted international standards such as IAEA, ISO, etc (Ref.03).

AECL recognized the emergence of ISO 9001 standards in the early 90’s and developed a number of processes to rationalize its products and services against the requirements of ISO 9000 series of standards. AECL saw the benefits from ISO certification in terms of increased global visibility as a certified supplier of nuclear products and services and to better relate to its international partners and suppliers.

AECL’s quality management system, based on the national & international nuclear standards, was internally examined against the requirements of ISO 9000 standards. A gap analysis and a transition plan were developed to obtain ISO 9001:2000 certifications. ISO compliance matrices were developed for all AECL’s life cycle programs. Some additional steps on the existing processes such as customer satisfaction, process approach, analysis of data and continual improvements were added to enhance its quality management system.

A number of groups across AECL sites that are involved in the various nuclear life cycle activities were audited by the Registrar (QMI / CSA) to examine their compliance against ISO 9001 system requirements. AECL used its quality management system; based on the applicable nuclear QA standards, and obtained ISO 9001 certification in a relatively short period without any major changes to its existing
AECL ISO certification covers all its sites and a broad scope of nuclear life cycle activities including Research & Development, Design & Engineering, Procurement, Manufacturing, Qualification Testing, Construction, Commissioning, Decommissioning, Waste Management; and

- Project Management for CANDU & Nuclear Power Plants, Research Reactors, Nuclear Facilities and Installations;
- Operation of Research Reactors and Nuclear Facilities

For its nuclear facilities and laboratories at Chalk River, AECL has also obtained certification to ISO 14001 for its Environmental Management System.

AECL has also successfully obtained accreditation for its analytical and chemistry services laboratories to ISO 17025 to perform chemical measurements covering radio nuclides, major ions, dissolved metals, etc.

AECL applied the same approach for securing its certification of its pressure boundary program against the requirements of ASME and CSA Code and standards.

For US offshore project in China, AECL used a similar approach to show compliance against the Chinese standards and IAEA 50 – C/SG-Q requirements.

During 2005/06, AECL has also demonstrated the compliance of its QMS against the requirements of US NRC CFR 50 App. B and ANSI 45.2 QA requirements in support of its nuclear services work in USA.

9. Conclusion

The integrated performance based approach to management system is a business imperative for the nuclear industry to survive in the current climate of deregulation, global competition and changing market environment. The compliance approach has served the industry well to protect its employees, neighborhood and public at large. It is well recognized that industry has to build on this experience and move to the next level.

The model described in this paper provides a fairly flexible approach to move towards a more integrated performance based approach to achieve both the compliance and business related goals and objectives. The compliance, quality and safety must remain a key focus for the industry. The model presented provides a practical approach to develop the business & compliance processes and documentation that can be integrated at the job and project execution level. The product and business performance objectives get embedded into the system documentation and implementation at all levels by the responsible line units. The model can be easily adapted to meet the requirements of applicable codes and standards and lends itself to obtain ISO & other system and product based certifications. The approach is consistent with the new IAEA direction on the management system requirements as covered in its new series of standards under GS-R-3 (Ref.04).

AECL has effectively used a part of these concepts and is further enhancing its management system to focus on customer satisfaction and performance measures. AECL has successfully applied these concepts to obtain its ISO certifications in a relatively short period without any major changes to its existing documentation structure.
10. Acknowledgements

The author acknowledges the support and encouragement provided by the AECL management and staff to develop some of the concepts for the IPBMS model. My special thanks to Dr. Heiki Tamm, (ex AECL, Director Corporate Quality Management) and Dr Aly M.Aly, AECL Chief Quality Officer for their support and guidance.

11. References


