IAEA-TECDOC-1651

Information Technology for Nuclear Power Plant Configuration Management

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

INFORMATION TECHNOLOGY FOR NUCLEAR POWER PLANT CONFIGURATION MANAGEMENT

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FOREWORD

Configuration management (CM) is an essential component of nuclear power plant design, construction and operation. The application of information technology (IT) offers a method to automate and ensure the timely and effective capture, processing and distribution of key nuclear power plant information to support CM principles and practical processes and procedures for implementation of CM at nuclear power plants.

This publication reviews some of the principles established in IAEA-TECDOC-1335, 'Configuration Management in Nuclear Power Plants.' It also recaps tenets laid out in IAEA-TECDOC-1284, 'Information Technology Impact on Nuclear Power Plant Documentation' that supports CM programmes. This publication has been developed in conjunction with and designed to support these other two publications. These three publications combined provide a comprehensive discussion on configuration management, information technology and the relationship between them. An extensive discussion is also provided in this publication on the role of the design basis of the facility and its control through the CM process throughout the facility's lifetime.

While this report was developed specifically for nuclear power plants, the principles discussed can be usefully applied to any high hazard nuclear facility.

The IAEA wishes to express its gratitude to all experts who contributed and participated in the drafting and review of this publication. Particular thanks are due to C. Wallen, K. Freeland and B.K. Grimes (USA) for their active and effective contribution to the project and their assistance in the compilation of this publication. The IAEA officers responsible for this publication were F. Hezoucky and J. Mandula of the Division of Nuclear Power.

CONTENTS

1. INTRODUCTION

1.1. Background

Effective configuration management (CM) is essential to the safe, reliable and economic operation of nuclear power plants. A significant number of the operating reactors in the world are over 20 years old. Many of the tools for effective configuration management were not available when these plants were designed and built. In numerous cases, the development of configuration management and the development of the mechanism for retention of design information were haphazard and inconsistent. The configuration management and software tools available today were not considered in original design and construction. This has presented a continuing challenge to the organizations responsible for safe and dependable plant operation.

Configuration management can be defined as the process of identifying and documenting the characteristics of a facility'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 facility documentation. The term 'configuration' is used in the sense of the physical, functional and operational characteristics of the structures, systems and components and parts of a facility.

The need for configuration management is a result of the need for the successful long term operation of any nuclear power plant. Some of the main challenges are caused by aging and out-of-date plant technology, ongoing plant modifications, and the application of new safety and operational requirements. Being able to capture this information and provide a mechanism for rapid and precise retrieval needs to be the goal of the personnel responsible for effective configuration management. Engineers who have ready access to design and licensing basis information are less likely to get bogged down in research and the hunt for relevant information. Engineers with ready access to important information are likely to make more intelligent decisions in a timely manner. The requirements to apply for configuration management are in IAEA Safety Standards Series No. GS-R-3, 'The Management System for Facilities and Activities Safety Requirements' [1].

An effective configuration management programme can provide other key financial and resource-related benefits. Operators of nuclear power plants who desire to extend the life of their plants will find the availability of design and licensing basis information to be a key component in providing information in support of an extended licence and may in fact be a condition of having an extended licence approved by the regulator. The same advantages can be realized for operators that plan to upgrade their plant power capacity. A power uprate submittal to the regulator can be more substantial and less costly to produce when the operator has improved configuration management tools. Also, the operators of plants that are candidates for shutdown and decommissioning can benefit from appropriate configuration management and related accessibility to design documentation in order to place their facilities in a safe shutdown condition.

The principal purposes of configuration management are:

- understand, maintain and document the plant design basis
- identify and maintain design authority
- support development of nuclear power plant business systems for master equipment list
- document control, design change, work management (WM) and materials
- management

- meet licence (authorization), design, and operating requirements
- design safe maintenance practices around the configuration management of work, components
- personnel, materials and procedures
- facilitate business re-engineering and process solutions for
- increased nuclear power plant capacity and operating economies
- demonstrate compliance to the regulatory body and to other ‘stakeholders,’ including the public
- reduce nuclear power plant trips and significant events
- understand and meet technical specifications and safe operating envelope.

The nuclear industry and government organizations are showing an increasing interest in the implementation of CM as an effective way of limiting configuration errors and related risks. In this publication the necessary attributes of effective operational CM are identified. It is recognized and emphasized that CM is one aspect, but an important aspect, of the overall management system.

A major concern with operating plants is their performance with respect to safety, reliability, and availability. Many nuclear power plants have increased their availability factors by more than 10 percent over the last 10 years and are reaching availability levels well above 80%. Modernization of the information technology (IT) tools for configuration management in nuclear power plants has been one of the important key factors in increasing plant availability. State-of-the-art IT systems can play an even more substantial role in increasing the availability of nuclear power plants to even higher levels in the future.

Computer technology is fast evolving and ever changing. What is considered to be ‘state-of-the-art’ one year can become outdated and classified as obsolete a few years later. One of the challenges facing the IT organization is to provide plant users with software that fills their needs and also stands the test of time. An additional challenge facing the IT organization is determining their customers’ wants and needs. In many cases the user cannot presume what best suits their needs without having a sense of what is available to them. Critical to the success of the new software design and deployment is the acceptance of the user. This can be helped but not guaranteed by proper customer involvement and input from the beginning, and by proper resources and support to the IT organization to help ensure their success.

1.2. Scope and structure

The concepts developed here represent a basic approach to the application of information technology to CM, considering experience gained from organizations and utilities that have successfully implemented configuration management. This publication focuses on the attributes of CM related to information retention and retrieval. While the term ‘CM Information Technology Solution’ is used to describe the integrated application of information technology to the configuration management process, the IT aspects are not the sole determinant of a successful CM process.

The initial sections of this publication address the major concepts of the CM process programme and detail some of the key data and databases. The initial sections also address the design change process and CM involvement in the change process to ensure proper updates to documentation. The relationship between CM and design basis and licensing (authorization) basis is also addressed. A discussion on the appropriate repository for documents and documentation that establish the design and licensing basis is provided.

The following sections of this report delineate the resources that are needed to assess the role of an IT programme within the setup, implementation and improvement of a configuration management programme to support the overall engineering and operational change process for existing nuclear power plants. It discussed how to develop and implement a configuration management programme for control of engineering records and operational documentation needed to maintain the licensing (authorization) basis and design basis of nuclear power facilities. The important aspect of reconstitution of the facility design basis is addressed in an Appendix to this publication.

This publication does not address details of the installation, post-installation and turnover processes for implementation of plant changes but addresses the interface with configuration management of these activities. It addresses all changes, including temporary ones, which are not intended to be permanent and are implemented on an interim basis to support plant operations, maintenance and start-up activity. It lays out what is required from a software programme to effectively support a strong CM programme, provides information related to information technology and organization and outlines the design of a configuration management software system. The CM software development process is detailed including functional and system specifications.

The appendices include a process for developing system and topical descriptions, case studies related to design basis reconstitution and process control software as well as sample architecture for IT processes and examples of types of legacy documents.

2. CONFIGURATION MANAGEMENT CONCEPTS

The concepts developed in this report provide a basic approach to CM, taking into consideration experience gained from organizations and utilities which have successfully implemented a partial or full configuration management programme and from discussions and meetings held on the subject.

Configuration management processes correctly applied will ensure that the construction, operation, maintenance and testing of a physical facility are in accordance with design requirements as expressed in the design documentation.

An important objective of a configuration management programme is to ensure that accurate information consistent with the physical and operational characteristics of the power plant is available in a timely manner for making safe, knowledgeable, and cost effective decisions with confidence. Typical programmes that directly support the three major elements of CM are shown in Figure 1. As discussed in IAEA-TECDOC-1335, in addition to the supporting facility configuration information programmes depicted in Figure 1, operational configuration, maintenance, and training information are also important components.

Main Functions of the configuration management process are to:

— maintain design requirements of structures, systems and components
— track current as-built drawings, documents, and design basis library
— confirm design change packages demonstrate compliance to design basis in calculations, procurement, safety reviews, update of affected documents, and SSC data
— confirm work orders demonstrate compliance to mandated preventive maintenance, surveillance, parts replacement and design change installation requirements
— demonstrate procurement of spare parts qualified to meet design basis for proper make, model and quality-level for the SSC location and form, fit and function.

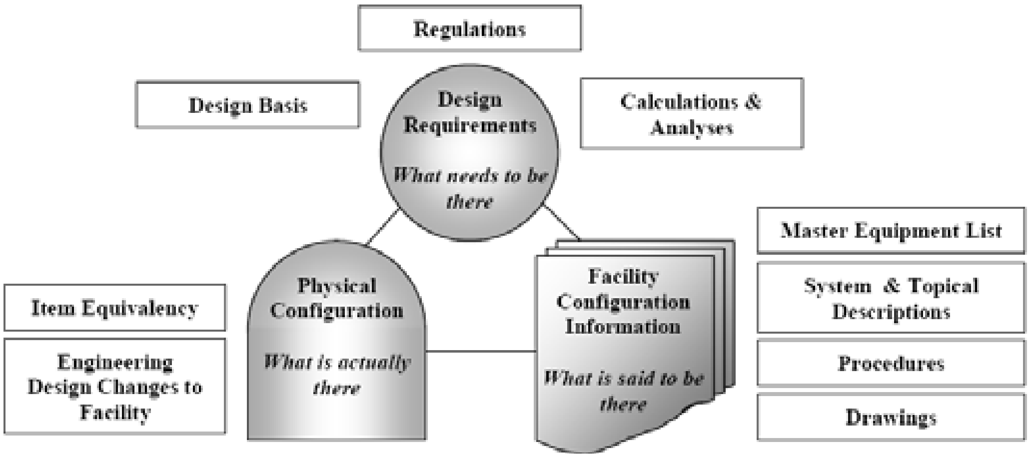


FIG. 1. CM Equilibrium diagram with selected related programmes

2.1. Design requirements and design basis

The design requirements are the output of the design process. The design basis (DB) provides the technical and analytical basis for the design requirements.

2.1.1. Design basis

The design requirement for the general design basis are stated in IAEA Safety Standards Series No. NS-R-1, 'Safety of Nuclear Power Plants: Design Safety Requirements' [2]. The design basis is 'the range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits by the planned operation of safety systems' (IAEA - Safety Glossary [3]). The design basis of the nuclear facility is used by the plant staff and the regulatory authority in judging the acceptability of the original design and of modifications to the plant with respect to the safety of the nuclear facility's personnel, the public and environment.

Information describing the nuclear power plant design basis can be reflected in system and technical descriptions, as discussed in Section 2.3.2. This information can come from specifications, criteria, codes, standards, analyses, constraints, qualifications, and limitations which determine the functions, interfaces, and expectations of a facility, structure, system or component.

2.1.2. Design requirements

The specific level of performance values required for systems and components can categorized as design requirements. In all cases, the system and components must be capable of exceeding the design requirements imposed on them. The difference between the requirements and actual performance is part of the plant's margin of safety.

These design requirements for systems and components can best be expressed in the form of parameters and values. These parameters can take the form of such values as capacity, voltage, flow, pressure, or temperature. The capture of design information in a design document library is discussed in Section 2.3.4.

2.2. Physical plant

The principal processes that control changes to the physical plant are the engineering design change process, the item equivalency process, and the work order process.

2.2.1. Engineering design changes

Design changes are the most significant way to modify and implement changes to the physical plant. A modification is any physical or functional change in the design or design basis of a plant structure, system, or component. A planned design change is accomplished within the requirements and limitations of applicable procedures, codes, standards, specifications, licences, and predetermined safety restrictions. These modifications may result in the addition, deletion, or replacement of components, systems, or structures. The design change process ensures that the desired level of quality is achieved and the needs of the station are addressed and that the physical plant changes are conducted within the design requirements and original design bases.

With respect to configuration management, the engineering change process ensures that the change is properly documented. Applicable programmes and documents that are affected by the Engineering Change Control (ECC) packages are identified and incorporated into the process. The ECC packages are an essential part of configuration management and must be included in the design document library (see Section 2.3.4).

As shown in Figure 2, engineering design changes take inputs from various sources to ensure configuration management is maintained. This figure also depicts the principal outputs of the engineering design change process.

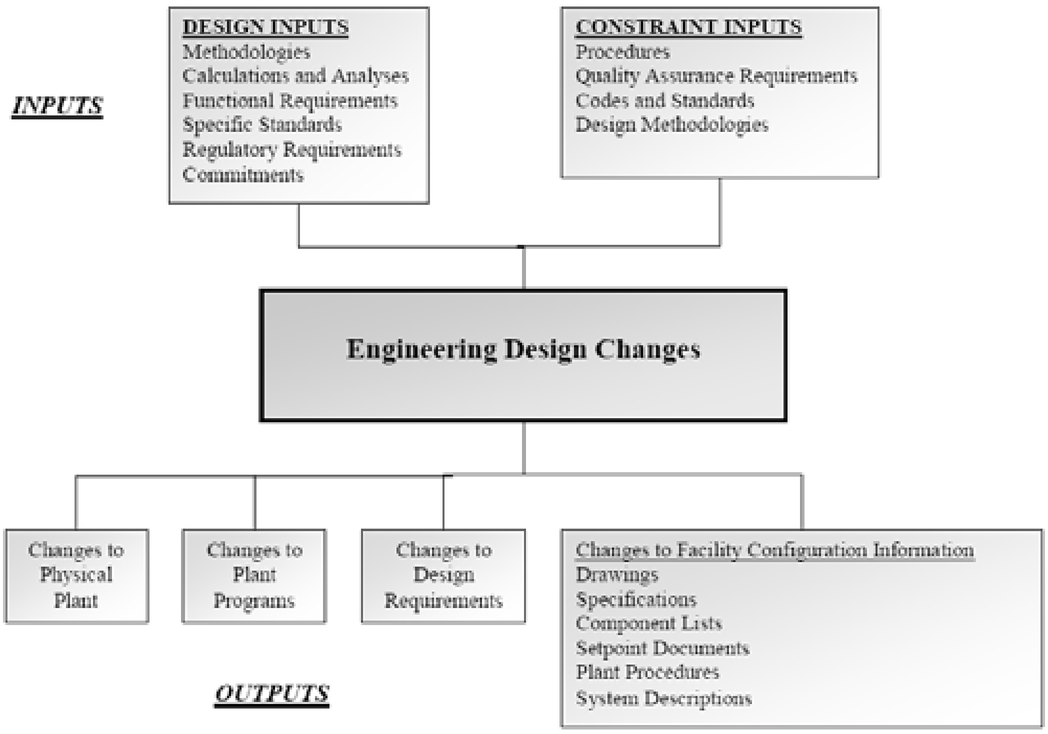


FIG. 2. Inputs and outputs to engineering design changes

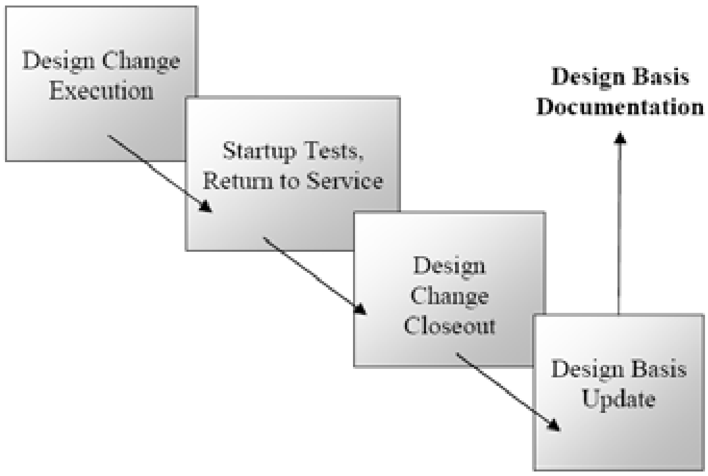


FIG. 3. Design basis and the design change process

2.2.2. Item equivalency evaluation

An item equivalency evaluation (IEE) is used for the replacement of components with similar but not identical components. The evaluation is typically performed (in advance of the procurement process) when it is known that:

(1) The performance of equivalency evaluations in advance of the need for a replacement item allows the station to ensure suitable replacements are in stock and limits the time necessary to replace a component.
(2) An item is determined to be 'equivalent' by ensuring that it will maintain the design basis of its intended application while complying with the plant licensing (authorization) basis.

The following questions should be answered by the equivalency evaluation:

(1) Is the ability and method of performing the design basis function the same as the original item?
(2) Do any changes in the design, qualification, fit or form adversely affect the ability of the item or the item's system to perform its design functions?
(3) Are the bounding technical requirements specified in the current design and licensing documents met? (Bounding technical requirements are those parameters of the design basis that define the function of the item.)

2.2.3. Work order process

Work performed on equipment at a nuclear facility that does not involve a change to the design and licensing basis or change to design basis information may be considered as maintenance activities and can be accomplished with work orders. Work orders can be 'stand-alone' or part of the engineering change process. Typically 'stand-alone' work orders are classified as corrective or preventive. The plant configuration should not be changed via 'stand alone' work orders. Work that requires change to the safety analysis report (SAR) or supporting documentation must be accomplished by higher tier documents such as engineering change requests in lieu of a work order. It is beneficial to electronically file work orders even if they are stand alone because the component level history of equipment can be preserved.

2.3. Facility configuration information

2.3.1. Facility configuration information overview

Facility configuration information consists of documented information that describes, specifies reports, certifies, or provides data related to the facility design requirements. This information can also relate to other information attributes associated with the facility and its structures, systems, and components.

Such information may be contained in original hard media, film, paper, magnetic tape, electronic media or other sources of information used to make sound technical decisions regarding procurement, modification, operation and maintenance of the facility.

The facility configuration information must be consistent with the plant physical configuration that is based on the design requirements. The facility configuration information includes as-built drawings. Changes to design requirements should be reflected in both the physical configuration and the facility configuration information.

As noted in IAEA-TECDOC-1335, facility configuration information also includes documents (including procedures) needed to maintain the plant operational configuration as well as documents that control maintenance and training. For example, the configuration of a plant-specific simulator must be maintained consistent with the facility configuration.

2.3.2. System and topical descriptions

System and topical descriptions (STD) contain an assimilation of information that represents the design and licensing basis of the nuclear facility. Design and maintenance of the STD can be implemented in one of two ways. The information contained in the documents can be considered actual design basis information or the information can be considered a roadmap to the design basis information. Even when the STD are not considered design basis information, due care and diligence should be exercised in development and revision activities, including referencing of appropriate design basis information. In either case, the STD need to be controlled with appropriate mechanisms in place to ensure they are properly updated and in a timely manner. Proper maintenance of the STD including timely updates to reflect the changes in the facility configuration will ensure acceptance by the engineering and other plant organizations.

The elements of an effective STD programme are presented in Appendix VI.

2.3.3. Master equipment list

The master equipment list (MEL) database represents the primary source for component and related parts information. The well-designed MEL contains local ID and component related information. A corresponding bill of materials (BOM) list contains the component and part level information that can be used for configuration control, equipment reliability, and maintenance operations. Identification of the correct spare part(s) facilitates the component's original design function(s), and therefore maintains the system and facility design configuration. Use of an electronic update process assists in the maintenance of the design configuration.

2.3.4. Design document library

Current and past design information for the nuclear facility can be captured in a design document library for use in support of various plant activities. This ensures that the detailed design is delineated and the design basis requirements are met with the detailed design properly documented in design process documents including calculations and analyses, and design output documents.

This design document library can help ensure that plant configuration documents are consistent with their supporting design process, and design output documents and are consistent with the design basis. Plant configuration documents include those controlled documents used to support various plant activities such as operations, maintenance, testing, procurement and training.

Objectives for the design document library can include to:

- Capture quality records immediately after creation and authentication
- Support unique, specific distribution requirements as determined by the record
- owner
- Identify and register new document and record types
- Identify and register collection/retention requirements
- Establish records indexing criteria based on specific users' needs to support
- retrieval
- Maintain and store records for security, access and management
- Integrate with existing CM systems to support nuclear power plant design, maintenance and operations activities

3. DESIGN BASIS RECONSTITUTION AND CM

In order to ensure that the CM process is on a solid basis, nuclear facility personnel may embark on a design basis reconstitution programme. This programme would perform the one-time task of identifying, retrieving, extracting, evaluating, verifying, validating, and regenerating missing critical design requirements and basis. This design reconstitution encompasses the functions of developing associated programme plans and procedures; identifying and retrieving design information from identified source documents; evaluating, verifying, and validating the design information; resolving discrepancies; regenerating missing critical design information; and developing system and topical descriptions. Once the reconstitution effort is complete, an effective CM programme will ensure that the design and licensing basis is maintained. IAEA requirements regarding design basis are stated in IAEA Safety Standards Series No. NS-R-1 [2].

A methodology for an effective design basis reconstitution programme as well as a design basis reconstitution case study is presented in Appendix III.

A practical discussion on the identification of the design bases is included in IAEA-TECDOC-1335 on configuration management in nuclear power plants [4]. Several aspects of the design basis reconstitution process have important implications for configuration management. These are summarized below.

3.1. Information linkage

The STD generated during the reconstitution process should be created in software that supports the linking process. An example of software that does this well is the Adobe Acrobat© ('pdf') document format. Acrobat© documents can be created with the ability to create hotlinks to other documents in the design basis library. The repository for these documents may be in separate types of software servers. The links to the documents that are expected to be updated may be dynamic. The link pointer should be to the document location and not an electronic file. If the source document is revised, the link will point to the revised document. With STD that are properly maintained and updated, any changes to the source documents that affect the system and topical Description will be identified and appropriate system and topical description change requests can be created. Links to documents that are not expected to be changed can be to the electronic file itself and need not be to a specific location.

The writer's guide that controls the development of the STD and provides guidance on format and content should give source document linkage information. Typically, the STD will have a references section that provides the links to all external source files including documents such as the safety analysis report (SAR) and operating licence. Any links cited within the body of the STD will direct the user to the references section that contains the external links. In this manner, the user can view information on the document cited before being directed to the actual source file. If the roadmap information in the STD is correctly created, the user will be directed to the needed file in an efficient and expeditious manner.

3.2. Updating deficient documents

Most of the documents for the older plants, including drawings, have been developed by hand, or by using software that is no longer in use, and which cannot translated to new software without a thorough verification. If reconstitution by electronic means is not possible for practical or economic reasons, reconstitution of the physical document is sometimes necessary. In that case the verification that the reconstituted document is identical with the original document has to be very thoroughly performed.

Design documentation can be affected not only by design changes, but also by the evolutions of safety standards and by periodic safety re-evaluations or generic issue evaluations even if no physical modification is initiated. Every time a new document affecting the configuration documentation is written or modified, it is necessary to check to ensure that all documents which can be affected by the new document or new information are modified as appropriate. A documentation management system that includes computerized links among documents can be a valuable tool in accomplishing this verification.

3.3. Creating data bases for information retention

As document software has evolved over the life of the facility, the electronic documentation may be constructed of different types and formats. A common format and relationship among these documents must be established. This can help comply with traceability requirements from the regulatory authorities as well as the needs of operation and maintenance. While the documentation of many older nuclear facilities is largely in paper form, it is advisable that at least the documents that undergo constant changes should be transformed into an electronic database format.

Hardware and software are rapidly evolving and quickly become obsolete. Some current document management systems do not separate the representation of the information and the way this information is implemented. For these types of systems, a common format should be considered for the archiving of documents. Such systems as 'pdf' for written documents and 'tif' for drawings should be considered.

4. INFORMATION TECHNOLOGY ORGANIZATION, PROCESSES AND SYSTEMS

4.1. Organization

A CM information technology solution will involve virtually all nuclear power plant organizations, to the extent that the organizations' functional and enterprise business requirements play a role in configuration management. The principal organizations involved in the development of the CM IT application, however, are:

- CM manager and oversight organization
- Information technology department
- Maintenance department
- Engineering and design change department.

In order for the CM organization to be able to plan and develop a CM IT solution, the following conditions should exist in the nuclear power plant, or at least be well on the way to implementation, prior to commencement of the project:

- Document owners identified
- Equipment ownership identified
- Potential data Sources and data ownership
- Engineering support data organization
- Basic nuclear power plant organization (document, engineering, parts/warehouse, procurement, WM , QA, training, operations) exists and recognizes data and functional (business process) responsibilities
- CM coordinator identified and assigned.

The nuclear power plant should include a CM manager in the organization to supervise and coordinate nuclear power plant activities related to configuration management in general, as well the as for the development and deployment of an IT solution for CM. The nuclear power plant CM manager should be responsible for the overall management and direction of the project to develop the IT solution.

The CM manager will usually oversee the development and deployment of the system, but the primary value of the CM manager is that of liaison and coordinator for gathering of requirements and business rules from the nuclear power plant organizations that require, use or provide configuration management data and processes. These organizations must also, in the end, accept the finished product, through their deployment of the product and ultimate integration into their work processes and business.

The CM manager should work together with the nuclear power plant information technology department and the IT manager to ensure the success of the IT solution. The IT manager is responsible for the information technology architecture utilized by the nuclear power plant for nuclear business, management and financial management of the plant.

In addition, the IT organization should be tasked with selection, application development and deployment, including work performed by vendors.

4.2. nuclear power plant software QA programme

The Software Quality Assurance (SQA) programme includes software testing, lifecycle management and software configuration management. This includes the audit, review and self-assessment, and nonconformance requirements applicable to other nuclear power plant quality activities.

The type and level of SQA assigned to a particular software application will depend upon its safety significance (see Section 4.6).

4.2.1. Software configuration management

The software configuration management is one aspect of the SQA programme. The configuration management of software includes software programme identification, supported systems software and versions, and documentation. The software QA programme requires the concept of software configuration management to ensure that the corresponding versions of applications, programme code, operating system, and other elements are matched for compatibility, and that the deployment of version-controlled software and hardware can be documented for location, hardware, version and users. IEEE Standard 828, 'Software Configuration Management Plans', Ref. [5] can be used to set up a Software CM programme.

Even consumables, such as optical media and memory cards, have manufacturing and revision lifecycles that complicate the ability to utilize, or read and write data, from these media. This is an important consideration when creating document and quality record archives.

A listing or database of servers, workstations and users hosting company owned software should be maintained to track software and applications on all company owned hardware.

The reasons for this include the need to:

- *Match software versions with operating system and other applications*
- *Manage requirements and contracts for Service Level Agreements() 0*
- *Determine software upgrade rules and eligibility based on product version, number of seats, and licence type (per-seat, concurrent or fixed workstation)*
- *Document software manufacturer product versions and serial numbers to maintain licence and EULA accountability for security, warranty, service agreements and commercial legal compliance*

Software QA also addresses software and hardware testing, and the concept of verification, validation and certification (V,V&C). Software testing and alignment with the appropriate software version and testing phase is tracked as well as interface relationships. Software creation, testing and deployment is tracked, managed and documented using configuration management principles similar to the configuration management of nuclear power plant equipment and parts.

4.3. Resources

The application of information technology relies upon qualified personnel and sufficient computing resources to ensure the ability to satisfy the functionality requirements of the CM solution proposed. The selection of technology and application programmes should be made in the context of available programming, hardware, network and personnel capabilities for the nuclear power plant. Cost of ownership for many enterprise-grade systems software can vary by region and locale, depending upon available programming talent and market forces. In addition, strategic plans or nuclear power plant owner corporate policies for hardware platforms or technology may determine the options available to the nuclear power plant for technology solutions.

Other recent options for technology deployment that are becoming available include SAAS (software as a service), SOA (service-oriented architecture) and other remote host and data management technologies emerging as a result of the internet and high capacity networking. These concepts must be reviewed and evaluated not only against cost/benefit, return and SLA requirements, but also in terms of nuclear power plant site and corporate policies for data security and proprietary requirements for the conduct of utility business.

4.4. Software lifecycle

All software products, versions and deployments have a finite lifecycle determined by one or more the following:

- *Software functional obsolescence* – Software no longer meets nuclear power plant's functional and business requirements, or modifications to do so are impractical
- *Loss or change of vendor* – software product source, support BPO or vendor are no longer available or willing to support the software
- *IT architecture* – software is found incompatible or impractical with a new or modified IT architecture
- *Software conflicts/incompatibility* – New or upgraded deployments of operating systems or supporting software no longer work well, or at all, with the application
- *Fundamental technology change* – Software product(s) based on a new or compelling technology comes available, which better supports underlying CM, maintain, repair and overhaul (MRO) or nuclear power plant business needs.

4.5. Business continuation

The business continuation plan is sometimes referred to as a 'disaster recovery' plan, and describes those processes and actions that are put in place before, during and after a postulated event which has the potential to interrupt IT and computing services or cause irreparable data loss.

Typical events which can trigger the business continuation plan include:

- Physical and natural disaster – fire, flood, storm, explosion, etc.
- Design-basis plant event resulting in operations movement to the EOF or site evacuation
- Internal (sabotage) and external security compromises
- External network (DNS events, virus attacks, etc.)
- Prevention of events affecting IT services and data integrity
- Protection to assets and mitigation of effects from an event
- Restoration of services and data access as soon as possible after the event.

The relative importance and urgency of service restoration is determined by how critical the service interruption and/or data loss will be to safe and viable operation of the nuclear power plant, the project and nuclear power plant site.

The nuclear power plant IT manager, together with the project manager, site manager and other key project management should ensure that the conditions under which business continuation plans must be activated have been defined, potential risk determined, and suitable plans for short-term operations recovery and long-term restoration of services and data.

The IT manager, as required, should develop, document and execute plans for events such as the following:

- Loss of partial or total network (LAN) operation or connections
- Loss of Wide-Area Network (WAN) connection to primary or supporting computing center, such as IP/VPN or T1 line loss
- Physical loss of, or inability to access, primary server/computing center and/or data repository
- Power loss
- Unauthorized physical penetration
- Unrecoverable loss of enterprise data
- Hardware casualties.

The IT manager should conduct pre-event planning for those events that center around redundant and installed-spare philosophies, such as extra servers, disk drives, and remote computing locations which may be switched into the nuclear power plant IT network. This planning should be based upon nuclear power plant procedures and safety requirements, and should be agreed by nuclear power plant and project management. The alternative computing facility contains applications, systems programmes and data to support essential plant safety, process, business and quality operations.

In addition the IT manager should develop a plan and process for the periodic backup of data from processing computers (servers). Backup media should be removable/portable and intended solely for the purpose of data recovery. Backup media should be removed and stored in a secure, such as a safe or strongbox rated for at least 4-hour fire resistance. In addition, duplicate backup media is created and removed from the nuclear power plant site or project facility to be kept in a remote secure location. Such facilities should be designed to minimize and manage risk of hardware and material failures, such as appropriate HVAC, fire retardant systems, cleanliness control, etc.

For physical and weather events, such as storm or disaster where IT services may no longer be processed at the primary IT center, business continuation switchover should take place as soon as possible. The IT manager would then inform affected users when, and what degree, of system access and functionality has been restored, along with any estimate of what was lost and how long temporary outages may last.

4.6. Software grading

Nuclear power plant software applications are graded to determine the handling, application and V, V&C requirements for the application. Many elements of safety and quality class criteria used in classification of nuclear power plant equipment and components reflect the requirement for the software to support normal and off-normal operations in a single-failure criteria environment, or meet safe-shutdown criteria. Software designated in this manner as ‘Safety-Related’ (SR) will be subject to strict benchmarking, preproduction testing regimens, performance documentation and other IEEE ‘828’, Ref. [5] and V, V&C requirements prior to live calculations being performed.

The safety related designation is normally placed upon design and calculation codes, such as engineering stress analysis, plant heat balance, electrical loading, core fuelling, and other computational-type applications which are employed for engineering design and normally have no direct configuration management application. Most nuclear power plant business software, such as a configuration management IT solution, is classified under an ‘augmented quality related' (AQR) programme where typical quality assurance checks, documents and audits are maintained on the software to ensure accuracy and business continuity, but no single-failure or technical specification criteria are applied to the performance of the software. nuclear power plant's may also choose to designate the software as non-safety related (NSR) if no Augmented Quality programme exists, but apply appropriate quality assurance provisions on a case by case basis.

Occasionally, MEL data from the IT CM solution database may be utilized for nuclear power plant main control room realtime SCADA or plant information systems (PIS), or in newer flat-panel screen control designs, used by operators to manipulate, isolate, tag and otherwise control plant equipment and systems. When this is the case, such data should be classified as safety-related only if the corresponding real-time data system is classified in the same manner, unless the regulatory authority or owner specifies otherwise. If so, the quality requirements to prove the integrity and accuracy of the plant equipment numbers, operating factors, alarm points, make/model and other equipment properties and data are similar to other safety-related data maintained by the nuclear power plant. The MEL application software used to populate the database may not be required to undergo safety-related V,V&C, if it can be shown that the data values and integrity are verified independently by audits, nuclear power plant walk-downs, or other means.

4.7. Platform and infrastructure

The 'Platform', also called technology or 'environment', for implementing a CM information technology solution is the physical processor hardware and supporting memory as well as the systems software, such as operating system, database managers and other technologies deployed by the nuclear power plant as its enterprise or strategic software. The selection of a 'platform' for computing automatically determines (and often limits) the types of programmes, applications, and even data formats that may be utilized for IT solutions at the nuclear power plant. This limit may extend to network software and devices and third-party applications, such as query languages and scheduling software.

IT platforms vary greatly in licence price and maintenance costs, and a careful analysis must be made to ensure that the price, performance and compatibility of the selected environment or technology meet the nuclear power plant expectations and budget. In addition, availability and cost of personnel trained in the selected technology should be taken into account, as well as compatibility to accommodate sharing and interchange of data with owner utility, suppliers and other nuclear power plant's. Examples of 'Platforms' include MS SQL-Server©, Sybase©, Oracle© and IBM DB2/SQL©, running on appropriate hardware. 'Open' architecture products (such as Oracle©) are designed to run on most major operating systems and hardware, such as UNIX, LINUX, VAX/VMS, IBM MVS/VS© and even MS-Windows Server©. Products such as IBM DB2© or MS SQL-Server© are more proprietary, and only run on their respective makers' operating systems.

4.8. Service level agreements and help desk

The IT organization establishes and commits to certain levels of service related to activities, types of software, and recovery times after outages and shutdowns. This SLA may differ for certain nuclear power plant users, such as operators in the main control room or emergency operating facility. In addition, the IT organization should establish a 'help desk' where users may phone or e-mail to report problems or ask questions about system and application functions. The help desk staff should be divided into hardware, systems/network, and application software divisions, and staffed by experienced, knowledgeable IT personnel in each respective area.

4.9. IT security for hardware and software

IT Security requirements address the availability, integrity, protection and stability of IT and data assets, to meet the goal of uninterrupted and recoverable data and application processing, service and storage. The IT organization has an enterprise commitment to the nuclear power plant to provide continuous, uninterrupted IT services, subject to agreed maintenance and deployment outages. In addition, the IT organization is committed to preserving data and software in a secure and stable environment, where data and programmes are maintained without data or software loss or corruption, and is accountable for configuration and ownership.

The IT manager should ensure that nuclear power plant and project data assets are kept physically secure, protected for integrity and defended from corruption or loss. Any data loss is unacceptable, but circumstances may occur when there is a threat of data loss beyond reasonable control. The IT manager should assess and manage these risks to ensure system availability without undue process, transaction or performance penalties.

A fundamental technique in managing data is to minimize, and/or reduce as necessary, the volume of data to be managed by the IT organization. A large amount of transactional data and intermediate results generated from processes may be discarded or, at least, committed to near-line, off-line or archival data storage for those data where retrieval performance and data recovery time is less critical. The IT manager, nuclear power plant site and project management should review these needs, to develop procedures describing plant and project processes involving data that should include data economy and grading, and to determine what data must be kept on-line, and what may be archived.

Those activities within the nuclear power plant project that produce large amounts of data, or data from specialized applications that require a particular storage scheme, such as dedicated server or server partition should be analyzed and described to the IT manager for creating the appropriate computing environment.

Enterprise data should be periodically backed up (copied) and relocated to a secure, protected location. The IT SLA should specify the time commitment the IT organization makes to restoration of eligible data when lost or erased, as well as which data to backup and restore under the terms of the SLA. The IT manager may select a backup scheme to meet the security and business continuation requirements of the application.

Generally, where capacity and backup bandwidth support it, all direct-access storage media (DASD) should be backed up at least incrementally or on a sliding interval. Other applications, particularly nuclear safety and process control, may require daily, hourly or backups of other time frequencies through a scheme that will provide the correct mirroring, error correction, dual-writing and checking.

4.10. Data ownership

Lack of data quality may be the single largest discernable cause for deterioration and eventual loss of confidence in enterprise IT solutions, and can lead to project failure.

Ownership of data supports security, quality and user acceptance of IT solutions. A designated data ‘owner’, such as the engineering manager, maintenance manager or materials manager, helps ensure the end-to-end quality of the data product and a high level of awareness of data quality.

Factors for ownership of data include:

- Data must be owned, in a fashion similar to nuclear power plant equipment and documents
- The owner must be an individual, not an organization (although the organization's members may create, review and revise the data)
- Many data items have a revision history which, similar to documents, must be indexed and associated with a design event that impacts the nuclear power plant design basis
- The design authority is the owner of the affected data as well.

5. DESIGN OF CM SOFTWARE

5.1. Overview

The data requirements for nuclear power plant configuration management, as described in Section 2 include a large amount of diverse information. This information, and the supporting information technology tools, must not only be complete and accurate, but accessible and available, to effectively support nuclear power plant configuration management and design basis–related activities. The systematic application of information technology to configuration management can help ensure that critical nuclear power plant data for design and CM is not lost, corrupted or misinterpreted.

Change management and personnel turnover is of great concern to today's nuclear power plants. As senior people retire and leave design organizations and the nuclear power plant, new young engineers and other nuclear power plant personnel are expected to take over critical plant activities, often without the benefit of receipt of valuable plant information from departing individuals. The continuity of essential nuclear power plant data is thereby placed at risk, with little chance of recovery other than through costly and cumbersome design basis reconstitution.

The data and processes that are established and developed for configuration management are extremely valuable, and should be shared with closely related plant processes and activities such as WM, materials management, purchasing, etc. It is quite practical to share this data and even some processes in the CM IT solution with these nuclear power plant activities, which go beyond the core CM scope, to encompass virtually all major nuclear power plant activities.

It is essential to plan for IT support of CM during preparation and construction of a new nuclear power plant. It is important to propose a data structure that will support nuclear power plant construction, commissioning, and operation. Data which is obtained during nuclear power plant construction will be well-utilized during operation as well. This concept is described in more detail in Section 5.6.

The following data is necessary for collection and storage from a CM perspective:

- Equipment data
- Design basis data
- Document databases (as-built, operational, regulatory documentation, etc.)
- Operational parameters
- Maintenance data.

The previously-mentioned databases should be under the control of a strong data management system (DMS) which facilitates tracking of data and documentation revisions, including tracking of data and document status.

nuclear power plants should utilize a data and document management workflow, review and approval process.

When the above-mentioned process is used at the nuclear power plant, more effective CM can be realized. Use of the CM IT solution for other existing nuclear power plant applications, or additional specific nuclear power plant applications that support CM can benefit from:

- Reduction of administrative burden
- Economies of scale; leverage CM data to other nuclear power plant applications
- Sharing of data from other nuclear power plant processes (especially financial control processes and asset management)
- Interlinking the activities of CM processes with nuclear power plant processes such as project management and change management.

Appendix V provides an example of the analysis, purchase, and installation of a CM IT solution.

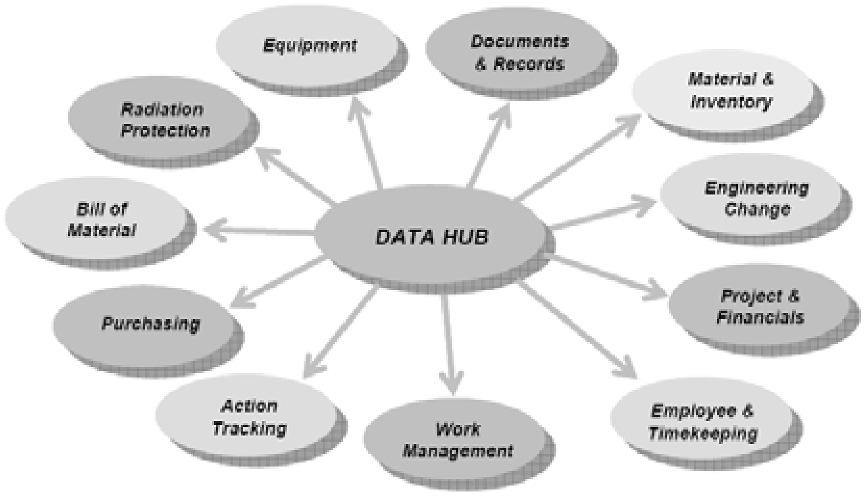


FIG. 4. Data hub concept for key relationships

Figure 4 illustrates the concept of a data 'hub' (i.e. central data source). This hub is utilized to store data and establish key data relationships (such as equipment to documents) which are then utilized in CM and design basis process, as well as other related nuclear power plant processes. The data hub illustrates the primary elements of a CM solution, and the fact that key relationships must be established to connect these elements to each other in a useful manner.

A properly designed and developed CM IT solution will have the following major attributes and positive effects of nuclear power plant management and operation:

- single, unified data repository
- temporal and cardinal links between plant data to create an nuclear power plant 'content and change history' and design basis repository
- implementation of nuclear power plant business rules and processes through software and other technology

- collateral benefits of nuclear power plant asset, project and financial management
- demonstration of control over nuclear power plant configuration to owner and
- regulator.

5.2. CM functionality

5.2.1. Overview of functionality

The CM IT solution, when complete, should meet the following general functional attributes in order to fully support the CM mission:

- Corporate and nuclear power plant commitment to establishing and incorporating the CM programme into the nuclear power plant business process is known
- A CM organization is in place to plan, design, implement, and better understand what is required for CM
- CM is identified as the integrating methodology for creating, maintaining, publishing and recording the nuclear power plant design basis
- The roles of various nuclear power plant organizations in the CM mission, including process owners, are identified
- Mechanisms are in place for all nuclear power plant organizations that affect, or are affected by, CM requirements and processes to carry out their CM-related responsibilities
- Core CM data repositories for the master equipment list, document control, design change, work management and materials management are in place
- The nuclear power plant IT infrastructure supports secure utilization of the CM IT solution
- Systems, applications and software that utilize applicable CM data for other related nuclear power plant activities are in place.

5.2.2. Software modules

The detailed design elements, considerations and steps for development of the CM technology solution are described later in this chapter. Each phase involves one or more decisions affecting the outcome and functionality of the final product. Table 1 lists the individual modules that provide the CM IT solution, or support the collection and/or use of CM data.

5.2.3. Procedures and process

Two approaches are described below for the CM IT solution.

(1) *Pre-designed CM software is implemented without modification to control and drive nuclear power plant processes and procedures in support of CM requirements* – The software runs the nuclear power plant processes, and the nuclear power plant agrees to accept all baseline functionality as compliant for the plant. Procedures are then written or modified based on the software functionality alone. This approach tends to favor purchase of a commercial IT solution for CM.

(2) *CM software is designed or customized to support existing nuclear power plant procedures and processes* –The business rules and processes are derived from the nuclear power plant's procedures. Software is then designed or modified to reflect these processes and rules. This approach tends to favor designing the IT solution in-house.

Table 1. The essential modules for the CM technology solution

Traditional CM Module Code	Key Elements	Data Hub?	PLM?
MEL	Component ID, Component Revision	Yes	BOM
DCR	Document Type, Subtype, Number, Sheet, Revision	Yes	Document
MMS	Catalog Stock Code, Q-Level	Yes	BOM
BOM	Manufacturer, Model, BOM Revision	Opt	BOM
PUR	Purchase Order Number, Line No, Revision, Release	Yes	BOM
EMP	Employee ID	Opt	Opt
WMA	Work Order Number, Task Number	Yes	MRO
FIN	Project Number, Task Number	ERP	ERP
ECC	Engineering Change Package ("Design Decision") Number	Yes	Design
ACT	Action/Commitment Item Number	Yes	Requirements
RPA	Radiation Work Permit Number	Opt	Opt

Since newly-constructed nuclear power plant's do not have legacy procedures to adapt software to, the process is somewhat simpler than a legacy nuclear power plant that has been operating and must now 'back-fit' existing procedures and process to the CM IT solution:

For new nuclear power plant and new CM systems

CM business model, rules and requirements are created first, and then CM processes and procedures are determined.

For legacy nuclear power plant and new CM systems

Existing procedures are reviewed, 'reverse-engineered' into the business processes. Then, business process alignment (BPA) is performed to create the business model for CM from existing functions plus industry standards and known CM requirements.

5.3. Fundamental decisions for CM information technology solutions

As noted above, one of the fundamental decisions for nuclear power plants considering CM technology solutions is whether to buy pre-written software or build a custom solution. There is a broad range of experience and opinions that determine the outcome of the decision. Since there is no unified correct answer for all nuclear power plants, the history of world nuclear power plants and operating utilities in making this decision offers potential insights into making informed decisions and evaluating the trade-offs of 'buy or build'.

Table 2 represents a matrix of advantages and disadvantages of the purchased solution versus in-house developed software. The general conclusion that may be drawn from this study is the balance of cost versus resources; those NP's having the sufficient IT and CM-fluent in-house resources will likely be most successful at designing and developing an IT system internally. Without this advantage, the requirement to purchase software, and possibly involve consultants in the implementation, will likely push total system cost higher.

Table 2. Commercial solution 'Buy-vs.-Build' decision matrix

Option	Advantages	Disadvantages
In-house CM solution	• Compatible with Existing Hardware • Use Existing Programming Resources • Build-to-Suit Custom Processes and Business Rules • Able to design data model, schemas and processing around existing legacy data • Can be modified/enhanced easily in-house • Lower development cost • Can grow with NPP needs	• Must design and develop specifications in house or with consultant • Responsible for own version control and software QA • Deployment risks must be managed in-house • Must be designed for NPP network infrastructure • Requires increased demand for in-house IT development expertise that may not be leveraged in future (or use consultant at increased cost)
Commercial CM Solution	• Industry Standard Nuclear Business Rules, functionality and processing • Seasoned and tested software platform • Integrated suite of modules • Limited customization is usually possible within software at little/no cost • Upgrades and enhancements from Vendor • NPP User group support and operating experience • Vendor-based solution; NPP IT relieved of version control, personnel, etc.	• Price generally higher than In-House Development • May require stronger network/infrastructure performance and capacity • May include modules or software not desired • Committed to Vendor for future upgrades, etc. • Major customization/enhancement will be costly • Still requires integration into NPP procedures, processes and work culture • Rejection of external software by NPP • Must migrate legacy data to unfamiliar platform

To help develop perspective for this complex process, the basic decision matrix involved in IT solution selection is summarized in as Table 3. The table shows, for each decision category, what the basic options are for the nuclear power plant to use in selecting both the approach (Buy or Build software) and the specific choices to be made.

Table 3. CM Technology project decision matrix

Architecture	Design	Procurement	Implementation	Deployment
❑ ENTERPRISE ❑ DISTRIBUTED	❑ DATA-DRIVEN ❑ PROCESS/PLM	❑ BUY ❑ BUILD ❑ CUSTOMIZE ❑ HYBRID	❑ PROCESS ❑ PROCEDURE	❑ NATIVE ❑ SOA/BPO ❑ HYBRID

Note: The term Plant Lifecycle management (*PLM)* is used to describe the workflow and CM control system utilized in some newer software solutions.

Each matrix attribute can generally be represented as a continuum, where no single attribute can accurately describe the final outcome, but the solution realized will likely combine elements of two or more of the attributes to some degree. The business criteria to be utilized for the selection of an nuclear power plant CM technology solution will parallel those of any major procurement decision, including those of purchase price vs. overall performance, initial solution cost vs. continuing programming and maintenance costs, and the amount of customization required vs. available business analyst resources. Some attributes are inter-related, and will be influenced by the other attribute values. For instance, if a CM IT solution is required to faithfully implement the specific procedures, business rules and work culture of a particular nuclear power plant without modification, indicating that an 'Out of Box' solution designed for general nuclear power plant implementation is unlikely to be a realistic choice in the same decision matrix.

5.4. Commercial system selection criteria

If the decision is made to purchase a commercial IT Solution for nuclear power plant CM, the following selection criteria should be considered in selecting and evaluating the available software on the market:

***Architecture* –** the system selected should be compatible with the functional needs of the system within the nuclear power plant target IT architecture and existing systems in use by the nuclear power plant.

***Functionality* –** nuclear processes and business rules that are included in the baseline CM software product design, including MEL, DCS, ECC, WM and MMS should be adaptable to those of the nuclear power plant. Comprehensive suites, such as those including the functionality above, plus accounts payable, labor entry, health physics, purchasing, inventory, procurement engineering, project management, equipment tag and clearance are available. The programming environments of newer products require little or no coding or computer language input. The system should serve equally well in the design, construction and operating phases of the nuclear power plant.

***Compatibility* –** ability to be integrated with other systems and programmes, as well as integration with target CAD, Document manager, and external data sources which are subsequently migrated to enterprise systems.

***Deployment Requirements* –** complexity and compatibility for network deployment, including the additional systems software and hardware required.

***Hardware Requirements* –** platform, operating system, and additional systems software required to implement.

***Vertical Integration* –** ability of the application suite to be scaled up and enhanced to meet the requirements of business processes as they evolve.

***Complexity* –** requirements for installation and use; also amount of supporting software needed.

***User Interface* –** how useable, intuitive and modern the user interface and features are. Level of effort users need to find their way to required functions.

***Horizontal Integration* –** ability of the application to be integrated with, or exchange data with, other applications which are, at least nominally, not specifically designed to integrate with the CM application but complement the purpose of the Enterprise application.

***Cost/Value* –** performance versus price, along with licence costs, implementation, hardware, maintenance costs, total cost of ownership (TCO).

***Availability in country* –** language is compatible, meets local and national legal requirements, can be purchased and deployed for national market.

***Maintainability* –** infrastructure and vendors located in country available for sales, maintenance, and upgrades.

***Source* –** where the software comes from or is made; what local sales and service capability is available.

***Market History (software references)* –** general position and perception in the nuclear power CM and asset management world.

***Management and Executive Features* –** ability to support data warehousing, report generation, and metrics for performance indicators.

5.5. Sources of CM and nuclear power plant data

The basic premise of the CM system design is that nuclear power plant data is created, maintained, and most importantly, passed from user to organization in an appropriate context, and then eventually to the nuclear power plant enterprise. This ‘three-tier’ architecture is a valuable design concept to help reconcile local data sources with the enterprise system and avoid user alienation and reluctance to participate fully in the CM technology programme.

A summary of data life from data generation (creator) through review, cleanup and approval providing validation and early revision life, and finally to the enterprise CM system for production use by nuclear power plant staff follows the pattern of:

5.5.1. Three tiers of nuclear power plant data management

Data generation: CADD, construction data, Intergraph PDS, simulation, CAE, engineering data sheets, action items, CARs, project management, etc. This function is frequently performed by the Architect/Engineer.

Review, cleanup and approval (validation): Document manager (EDMS), engineering workflow & routing (eProcess EDR), action tracking. This function must be performed by the data or document owner.

Enterprise asset and CM system: MEL, DCM, ECC, materials, work management, etc. used for plant operation.

The majority of nuclear power plant and CM data is created, processed and finally utilized for nuclear power plant workflow according to the flowchart in Figure 6. As shown in the chart, raw data originates from design outputs, such as CAD drawings, calculations, initial component lists and bills of materials. Data collection is performed by document management and CAD/CAE systems, transported to design reviewers and managers via an office process control software or PLM solution, then upon approval by the data or document owner, published to the enterprise CM solution for nuclear power plant work. In the case of financial-based work processes, financial data will then be delivered to the enterprise system for reconciliation. Financials are not a direct CM function, and this process is described more fully in Appendix V.

Figure 5 illustrates some of the key relationships, as well as the suggested workflow, for the three tiers of nuclear power plant data management. The first three phases correspond to the 3 ‘Tiers’ of data development described above. Through these phases, data is created, reviewed by owners, and prepared for production use in an enterprise nuclear information system. A fourth phase, ‘Reconcile’ is a financial element and, while not directly related to CM or DB, has an overall benefit to configuration management and asset management through the tracking and delivery of cost and project data to the accounting and enterprise resource planning (ERP) systems.

In order for nuclear power plant data to be reliable and of high quality for plant design, the process described in Figure 5 depends upon two additional nuclear power plant resources:

- A document management IT solution that controls document owner’s vintage (version), attributes and metadata prior to commitment or publication to the enterprise CM system
- An engineering design workflow or PLM IT solution to manage the flow of data, documents, comments and changes among reviewers and approvers prior to document or data publication.

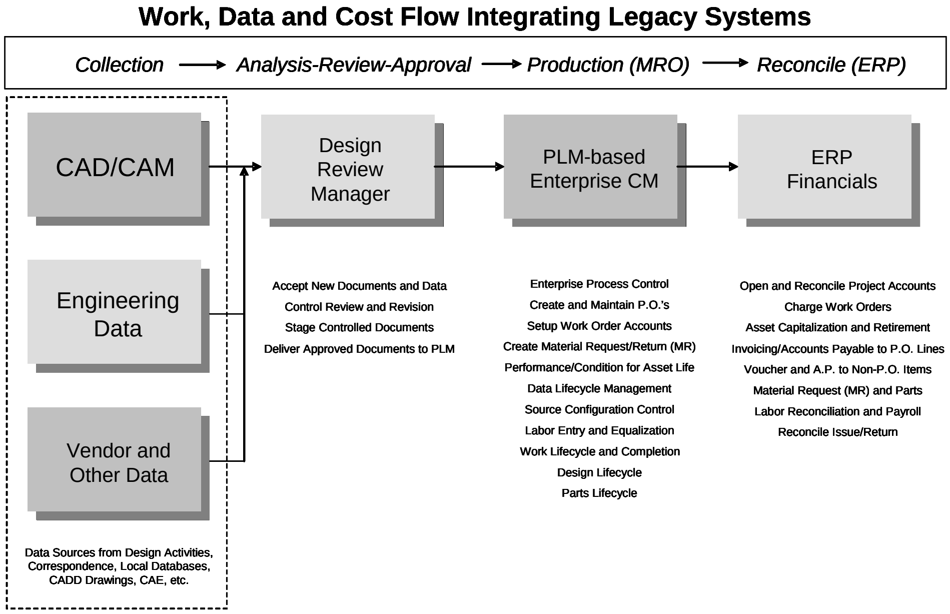


FIG. 5. Nuclear power plant and CM data generation and utilization in nuclear power plant workflow

5.6. CM functions for design and construction of nuclear power plants

CM activities and elements usually identified with plant operation have equivalent activities during the design and construction of the nuclear power plant. The chart below describes this relationship.

Table 4 describes the relationships between traditional nuclear power plant operating configuration management functions, and where they correspond to nuclear power plant design and construction work processes and requirements. Table 4 also describes the asset management and other selected functions of each CM element, where appropriate, as a collateral benefit in addition to the configuration management features of the selected CM software solution. Figure 6 indicates the various CM process functions applicable at various stages of the plant life.

PLANT PHASE	EQUIPMENT	DOCUMENTS	DESIGN CHANGES	WORK ORDERS	PURCHASING	MATERIALS CATALOG	RECORDS
Design & Construction	✓	✓	✓		✓		✓
Start-up & Testing	✓	✓	✓	✓	✓	✓	✓
Commissioning & Operation	✓	✓	✓	✓	✓	✓	✓
Decommissioning	✓	✓					✓

FIG. 6.nuclear power plant design phases and CM

Table 4. Translation of design and construction CM to nuclear power plant operations phase

Item No	Design/Construction Function	Production CM Function	Asset Management Benefit	Notes
1	Equipment List	MEL Asset Registry	Identify Depreciable Assets in Sufficient Detail to track performance and condition history	The Designer should provide the financial information necessary to convert equipment records into Asset Registry entries.
2	Document List	Nuclear Controlled Documents	No	From commencement of work, documents utilized for plant construction should be controlled in a fashion similar to those for production operation.
3	Shop Orders	Installation work orders	Yes	Designers and constructors frequently issue shop orders to control the specification purchase, installation and testing of a component or system.
4	Design Decisions	Engineering Design Changes	Yes	Accounting for Drawings, Documents, Parts and DB support may require conversion of records from constructor.
5	Inventory Shop Orders Receipt Records	Inventory	Yes	The receiving, MQR/QC, and Issue/Return processes normally tracked at a production nuclear power plant may be contained in the Shop Order or in other disparate records.
6	Shop Orders	Purchase Orders	Yes	Purchase Order change numbers, lines and Part Numbers (Stock Codes) will likely be contained in the shop order. Items such as cycle counts and Avg Unit Price will be known by the constructor, and may not useable for initial values in production.
7	Manufacturer Bills of Material	Bills of Material	No	May not be provided with initial component delivery, because Designer will be performing procurement engineering Functions. These and corresponding Vendor Manuals (VMs) should be acquired.
8	Engineering Punch List	Action Tracking	Yes	Issues, Regulatory and QA Actions identified during construction may be combined with engineering punch list items. This could include resolving Tech Specs and LCO requirements to specific components, etc.
9	Serial Numbered Items	Uniquely-Tracked Commodity (UTC)	Yes	Assign token UTC number to track during Production
10	Construction Records	Quality Records Management	Yes	Conversion may be required from the Constructor's classification system to an NQA-1 or 10 CFR 50-type systems.
11	Shop Maintenance	PM work orders	Yes	Components shipped to the construction site will be subject to in-storage maintenance prior to installation, and certain PM requirements even prior to system or nuclear power plant commissioning. These procedures must be developed during the engineering processes for both construction and production operation.

Plant Schedule Phase	IT Activity for this Phase	Hardware Deployments	Software/Solutions or Enhancements	A/E	NPP Site	EPC
Completion of Detailed Design	• Implement LAN Design Infrastructure • Develop "Repository" (Hub) CM Applications • Implement Engineering Process Control • Implement Document Management	• Owner Server Center • Routers, Work-stations	• Master Equipment List • Document Control • Engineering Design Control • Engineering Process Control • Document Management System • Scheduling and Project Management	• Servers • LAN • Routers • Workstations • Document Center	• Routers • Work-stations • Document Center	• Work-stations
Complete Technical Design	• Implement CADD and CAE systems • Integrate CAE with Document Management and Equipment List	• CADD Center and work-stations	• Procurement Engineering • Materials Catalog • CADD/CAE Interfaces • Work Management • Project Management	• CADD Center	• Document Center • CADD facility	
Commence Detailed Design Reviews	• Review Engineering Process Control		• Engineering Process Control • Document Management System • Scheduling and Project Management			• Work-stations
Commence As-Built Design Reviews	• Review Engineering Design Process design		• Associates and Air/Power Supply • DCN/FCR Facility			• Work-stations
Construction	• Review Document Control system for construction compliance • NPP IT Organization • NPP Secure IT Facility • Programmers • Systems Support • NPP Site Doc Control	• NPP Site Server • Network Infra-structure • POS and Wireless Data	• Work Management • Project Management • Labor Entry • Exposure Control • Engineering Change Control (FCR/DCN) • Inventory/Warehouse • Receiving/QC	• Server backup and recovery • Referential dual data	• Servers • Routers • Workstations • Wireless Data Systems	
Commissioning	• IT Organization accepts turnover of Software and Applications	• Server movement	• Exposure Control Forms • Work Management Warranty Tracking		• Servers • Routers • Work-stations	

FIG. 7. Sample deployment plan for IT resources during nuclear power plant site construction

Plant Schedule Phase	IT Activity for this Phase	Hardware Deployments	Software/Solutions or Enhancements	A/E	NPP Site	EPC
Post Commission/Acceptance	• Selection and Purchasing of software		• Personnel/HR • Training • Qualification • Scheduling and Outage Control			
Vendor Qualification and Procurement Package Review	• Document Management migration		• Procurement Engineering • Document Management • Engineering Process Control • Purchasing & Standards			
Vendor Documents	• Document Management and Document Control Interface		• Catalog/Manufacturer Facility			
Shop Surveillance and QC		• POS and Wireless Data	• Work Management Surveillance enhancements		• Work-stations	

FIG. 7. Sample deployment plan for IT resources during nuclear power plant site construction, cont.

Figure 7 describes CM and IT-based activities according to the timing of implementation with plant design and construction phases, both at engineering activities and on-site., and illustrates the optimal timing and best schedule for implementation of configuration management and related IT functions during nuclear power plant design, construction and commissioning phases. This will guide the nuclear power plant to selecting the best time to deploy a particular part of the information technology plan without acquiring hardware, software or other costly elements too early, incurring costs too early, or acquiring them too late for timely deployment.

As an overview, Figure 7 shows the acquisition of sufficient hardware, software and network infrastructure to meet the business requirements of each nuclear power plant development stage. During the design process, basic network infrastructure is required to provide a means to distribute, review, resolve comments and approve design documents and drawings. This infrastructure would be ideally extended to the EPC contractor, architect/engineer and any major subcontractors involved in the design phase. As construction begins, the IT infrastructure at the site must be in place to extend the computer network to construction venues and activities. From a software standpoint, the master equipment list, document control and engineering design change facilities must now be joined by work management and materials catalog applications. The work management functions are utilized to track installation progress and data during component installation, while the materials catalog and inventory are utilized to start managing receipt, inspection and storage of components and materials on site until installation, as well as in storage for long-lead components requiring shelf-life maintenance or controls. The configuration management of nuclear power plant design and the installed components is utilized during inspection, startup testing and QA review of design. The commissioning and operation phases of the nuclear power plant indicate the deployment of utility-specific and operating requirements, such as procurement engineering (if not already established during purchasing for the nuclear power plant design), radiation protection, training and qualification, and personnel needs. Some functions of this type, such as labor entry or scheduling and outage control, may likely be installed during construction to meet project development and management requirements.

5.7. System maintenance and lifecycle

The IT system lifecycle is determined by a combination of technology lifespan and cost factors. Obsolescence for software occurs in different ways, and can be handled by upgrade (enhancement) or eventual replacement with more advanced software. System maintenance by vendor or in-house technical staff can have a great influence on the useful life of a given solution. Selecting a contractor for the CM system maintenance and enhancement will depend largely upon:

- Technology selected
- How involved nuclear power plant was in system development
- Comfort level of nuclear power plant IT organization with the system
- In-house nuclear power plant talent and resources available
- Availability of qualified vendor or consultant.

A consultant or contractor not involved in the system development will require additional time to learn the system, and in any event does not own the nuclear power plant design and may not be as committed to the design’s success. Nuclear power plant or utility rules or culture may limit the amount and type of external consulting accepted, as well as place limits on design or data disclosure to third parties. When evaluating the service life and ongoing compatibility of a solution, the following should be considered:

- nuclear power plant may wish to 'hedge its bets' by not committing to, or over-investing in, a sunset technology unless there is a compelling financial, political or cultural reason for this
- The IT architecture and processing platform must be forward compatible also, as they usually become obsolete before the application (and its functionality) does.

The risk of obsolescence can also be minimized by considering industry acceptance, market share, available resources, flexibility, and broad compatibility.

5.8. Sample functional areas for CM functionality requirements

5.8.1. Overview

The review of the sample IT solution design for CM in this section will focus on five basic function modules needed by nuclear power plants to implement and support essential configuration management. Figure 8 shows the module and corresponding section of this report where the module is discussed. The 'owner' of each functional area and the associated owner responsibilities are indicated for each of the five modules in the referenced Sections. The data element(s) beneath each module title represent the suggested data most likely to serve as simple, logical keys to be used in relating these 5 modules to each other.

Each of the following sections describes one module of functionality for the basic configuration management IT Solution. One element of the module descriptions is a graphic chart describing the purpose, principal data keys and metadata, major CM functions and procedural steps required to implement the module. These charts may be used as a quick-reference guide to understand CM requirements and evaluate potential procedural and technology solutions.

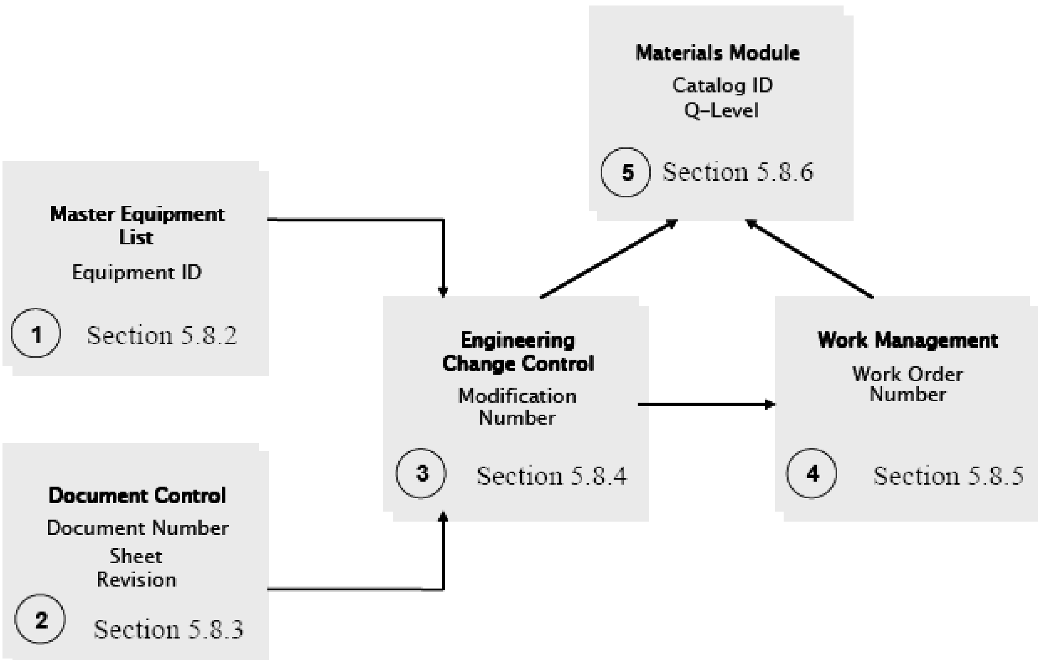


FIG. 8. Basic configuration management 'modules' representing basic functionality

5.8.2. Master equipment list module

This Section is a view of MEL and associated data as a ‘document’ to be reviewed, approved, issued with a revision history, and changed and updated as necessary for plant changes or error correction.

Owner:

Design engineering or design authority organization, represented by nuclear power plant technical services or nuclear power plant design engineering.

Responsible for:

- Data collection, review, validation and input
- Component design basis verification
- Data entry organization
- Data update procedures
- Data update request (DUR) (as well as DCR/Document change requests).

An instance of the importance of proper up-front planning for CM and asset management is the MEL. The structure of the equipment items, components, sub-assemblies, skids and other equipment formats will impact nearly all other design decisions made for the IT CM solution, and therefore must be carefully defined.

Figure 9 illustrates the selection of equipment nesting or ‘parent-child’ relationships, and other aspects of designing the MEL. Understanding these relationships becomes important when the plant designer attempts to reconcile equipment names and locations with the specific components installed to meet the design basis and performance requirements of the design. The design requirements, design basis and flow diagram drawings represent the ‘logical’ equipment location and usually refer to the ‘Parent’ level equipment identification. Components are the ‘physical’ elements of the equipment item, and are normally identified by a manufacturer name and model. The location of the physical component is established by reference to the ‘Parent’ or Equipment-level item, and are usually referenced by most other nuclear power plant configuration management keys, such as work orders, procurement evaluations, purchase orders and some documents.

This relationship will aid in reconciling the requirements of design basis maintenance, configuration control, parts allocation and work management. The other linked modules will use the MEL elements in establishing additional data relationships. The MEL directly affects more data entities than any other single module, and may be represented in over 90% of data transactions in an enterprise CM system.

Appendix V provides a functional checklist for an equipment and component data structure in the MEL module.

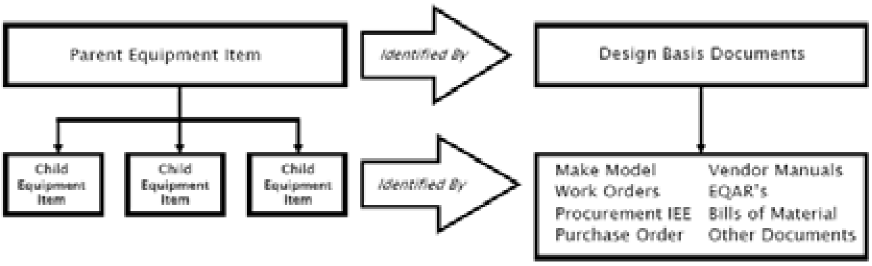


FIG. 9. Equipment/component ‘parent’ and ‘child’ relationships and rationale

5.8.3. *Document control and records management module*

This module collects and manages document and record data as related to document lifecycle. This includes receiving of document/record media, reproduction, controlled distribution as instructed by the document owner, and the archiving of superseded or replaced documents.

Owner:

Document management or document control organization, which is usually part of the nuclear power plant design engineering, but is sometimes under the quality assurance or IT organizations.

Responsible for:

- Document and records receipt
- Data entry/validation of document attribute data
- Reproduction of media and paper sizes according to document guidelines from document owner
- Management of document life cycle
- Controlled distribution of documents as per distribution list from document owner.

Figure 10 describes typical document and record review and processing details. Typically, documents are tracked by the document number, sheet number (if available) and revision number. The Revision is controlled by the document owner, who reviews, revises and approves the document through the document management system. Implementation pre-requisites are also listed.

The relationship between document management and nuclear document control are shown below in Figure 11. Document management is aimed at the creation, review and control of document content. When document owners approve the content of a document, the revision is delivered to the nuclear document control organization. The responsibility of the nuclear document control organization is to control revisions and to appropriately distribute the document.

In Figure 11, two stages of document lifecycle are depicted. In the top half of the picture, where document management takes place, the document owner creates reviews and approves the document. Examples of potential occasions for a quality or design basis document being created include engineering design changes, procurement specification changes, plant procedure or work instruction changes, licensing requirement or removal of redundant equipment. This process assumes that a system is in place to identify and task document owners with the review and update, as necessary of controlled documents under their control. The bottom half of the picture is where the document owner approves the final document and submits the document to the document control center for control, distribution and archival as a quality nuclear power plant record. The document is then distributed as per the document owner's distribution list to nuclear power plant personnel for plant work. The process for controlled distribution to the nuclear power plant includes the QA requirement for documented transmittal of the document and acknowledgement of receipt by the copyholder.

Figure 12 describes the detailed elements of these relationships and differences in more detail, breaking down the comparison by document control function and activity. This comparison is useful in the evaluation and selection of document management and nuclear document control products by functionality. Both are necessary for an integrated document control solution; products selected for each role should be compatible for architecture, functionality and data migration.

Functionality:

Document is Attribute for Work Order
One or more Documents for given W.O.
Can be affected by W.O for BOM/Parts
Determined by Equipment/System

Metadata and Relationships:

Document Number
Sheet
Revision

Document Lifecycle	System Used	
	Owner Review	*Approval and Issue*
Creation and/or Review	**Document Management**	
Revision or Supersede/Replace	**Document Management**	**Document Control**
Approval and Issue	**Document Management**	**Document Control**
Distribution and Control		**Document Control**
Quality Records Archive		**Document Control***

*Records Management

To Implement:

- Document Needs and Requirements
- Define and determine document process
- Determine Technology

FIG. 10. Document processing

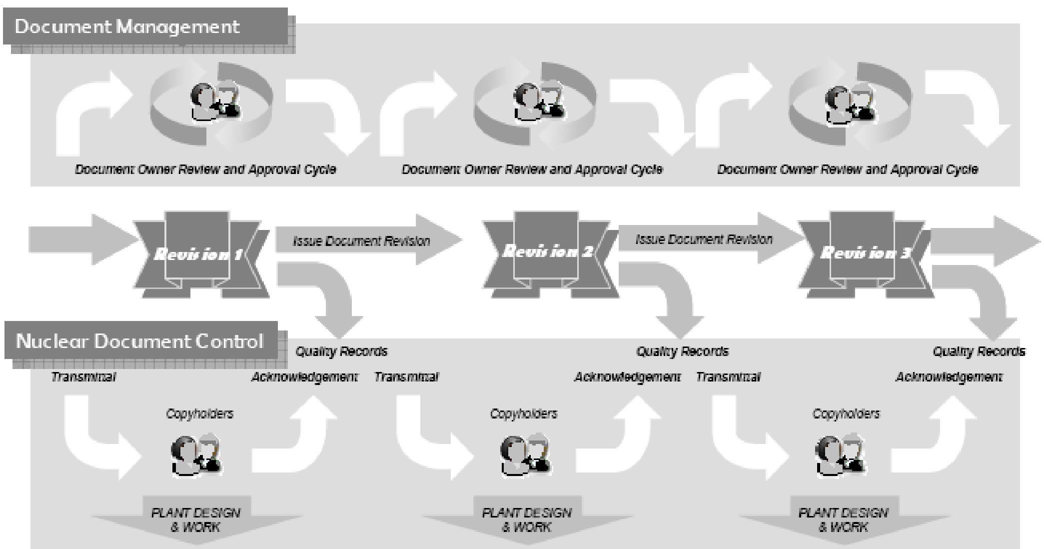


FIG. 11. Controlled document revision lifecycle through document management and nuclear document control

No.	Item	Nuclear Document Control Module	Document Manager (ISO 9001)	Comments
1	Track Identity of Controlled Document	X	X	Document ID Number, Owner, Reviewers, Approvers, etc.
2	Support Document No-Sheet Number-Revision ID format	X		Must support Sheet Numbers for drawings. Document Type and Sub-type references are preferred also
3	Track current and previous versions of controlled documents	X	X	Includes replaced documents, documents combined into one and other document pedigree.
4	Track distribution of controlled documents by distribution type, group, individual	X		Includes Controlled, Working and Information-Only copies distributed and used for work in the plant.
5	Track and prompt for document biennial reviews	X	X	Required for certain Critical Plant Documents and safety-related systems
6	Track Quality records	X	X	Related records information for dates, creator, owner, content, etc.
7	Control minor changes	X		Small changes not requiring new revision – permit up to 5
8	Identify Reference Documents	X		Documents not distributed but still controlled
9	Control of Vendor Manuals and documents	X		Special requirements for update and insertion, usually without new issue of entire document
10	Control Review Cycle by reviewers and approval		X	Office Processing-type programs; controls review cycle
11	Associate related Design Changes to Documents effected by the change (including DBD's)	X		Engineering design changes must identify those documents affected by the design, and ensure that they are updated, combined, cancelled or created as required to document the design.
12	Relate Documents to Plant Equipment, Spares, UTC's	X		Plant Equipment Tag Numbers, Component ID's, Catalog ID/Stock Codes of Spare parts and Serial Numbers of Uniquely Tracked Commodities (UTC) as principal key links between data tables.
13	Document/Record Storage Locations	X		Includes vaults, satellite stations, offsite repositories
14	Create Procedure Index	X		Frequent Regulator requirement
15	Ability to track alternative media	X	X	Track documents and records on media other than paper or aperture cards, such as CD-ROM's. Utilize QA standard such as USNRC GL 88-18.
16	Track Design Basis Documents (DBD's)	X		Requirement to maintain Design Basis, FSAR, licensing requirements as well as functional design basis for plant design and engineering changes.

FIG. 12. Key differences between document management and nuclear document control

5.8.4. Engineering change control module

The ECC process is the nuclear power plant control point for design basis and CM, and manages change to nuclear power plant equipment and systems. One equipment change event includes consideration of the design basis, parts, documents, bills of materials, qualification programmes, safety screening and review.

Owner:

Design engineering, represented by nuclear power plant Design engineering director or design authority.

Responsible for:

- Collection, evaluation and entry of engineering change requests
- Consolidation of engineering change requests into design change/modification numbers
- Creation of work orders for implementation
- Creation of preventive maintenance provisions PM's required for design change system/components
- Review and entry of affected equipment, documents, bills of material
- Submission of the completed and closed design package as a quality record.

Figure 13 describes an overview of functions, processes and activities involved in the engineering design change process for CM purposes.

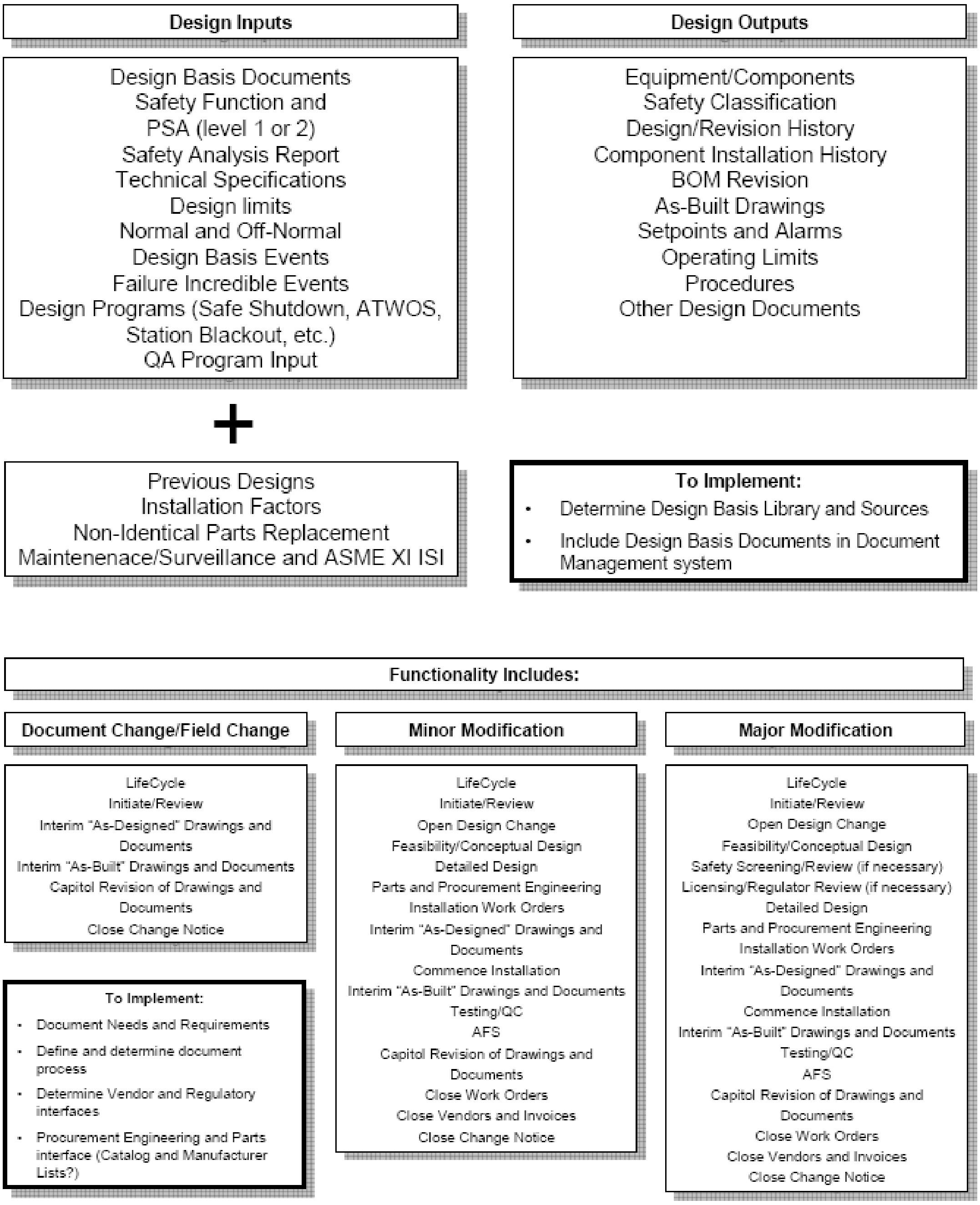


FIG. 13. Engineering design change functions and activities

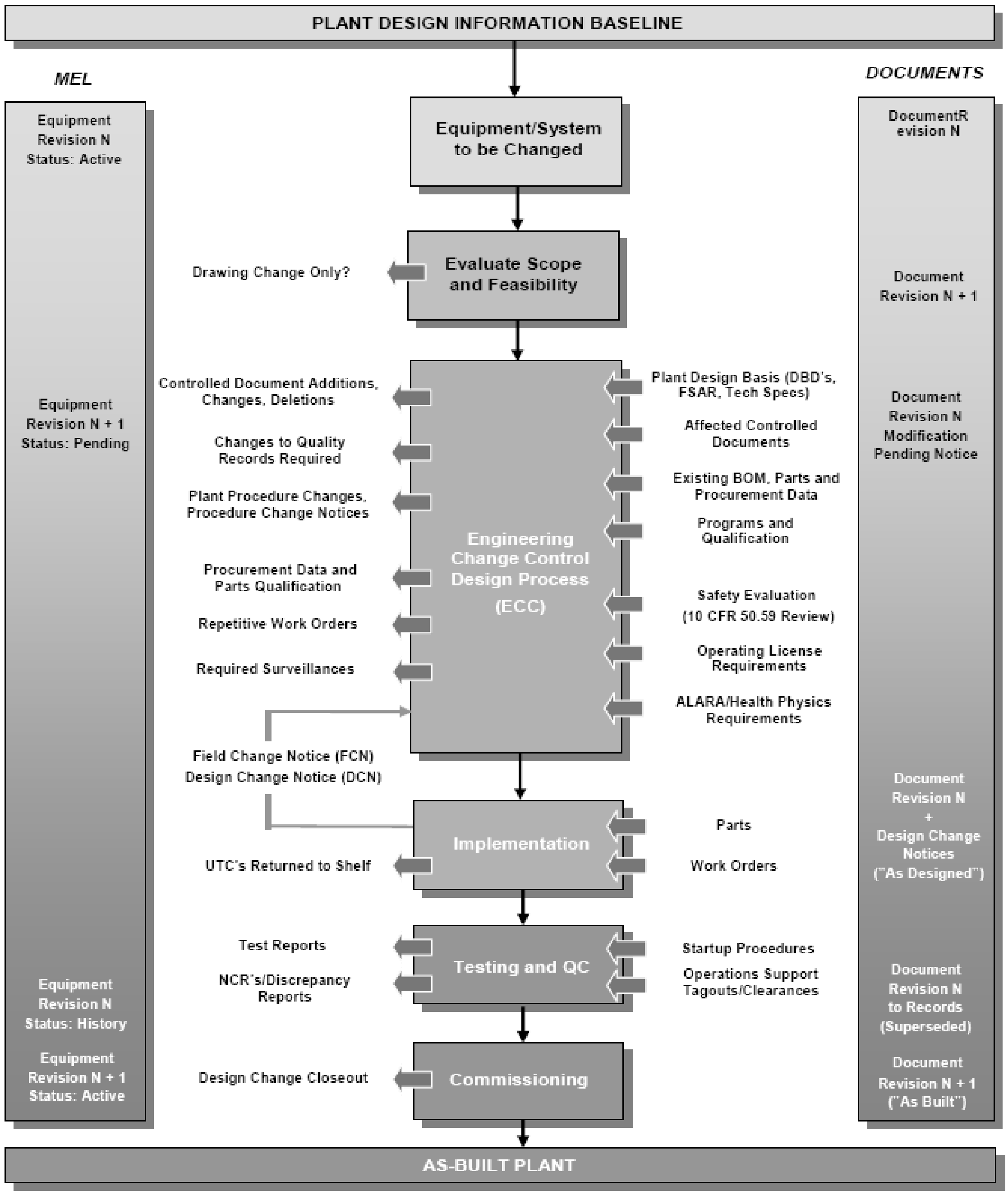


FIG. 14. Engineering design change workflow and revision control

Figure 14 describes the overall engineering design change process in terms of both activities and the how the engineering design change process controls configuration change and version indexing of equipment, documents and the nuclear power plant design basis. Equipment and documents affected by the design change receive a revision number increase as required to reflect the change. This revision number may then be linked back to the design change where it was initiated to manage the configuration, and to account for any design basis changes that may have occurred in the design.

An important observation to be made from Figure 14 is the method and process by which equipment items and controlled documents related to the engineering design change and modified. nuclear power plant equipment and documents should, with very few exceptions, only be changed in association with an approved and documented, engineering change. The process of change to the equipment and documents involved is synchronized to the stages of the engineering change process. This chart also illustrates the concepts that the engineering design change to a component or system increments the version of the equipment, and the documents associated with the equipment, and that the sum of the nuclear power plant engineering changes, considered together, represent the complete progression from the baseline nuclear power plant design to the current as-built plant and will intrinsically contain the plant design basis.

5.8.5. Work management module

The work management module assigns work orders to MEL equipment items, systems, stock code, UTC or charge number (for contractor/vendor), tracks progress and collects results and data from Work order closeout.

Owner:

Nuclear power plant technical department manager or plant manager

Responsible for:

- Collection and consolidation of work requests
- Entry of work orders
- Scheduling of CM, PM, outage and design change work orders
- Update of status dates
- Recording of failure modes, root causes and surveillance failures
- Entry of work closeout and asset management data

Data is updated through only one of the following:

- Work request
- Work order

The work management module can also generate:

- Work requests
- Design change evaluation request
- Design change evaluation request (DCR/DUR)
- Action item/commitment.

Figure 15 describes the process of work requests collected and formed into one or more work orders, and the organization of the work order into Tasks and, optionally, Discipline categories for execution, and illustrates the reasons and expected results for work orders. work orders collect and retain a great deal of plant reliability and component history data, which have the potential to affect nuclear power plant configuration management decisions and actions.

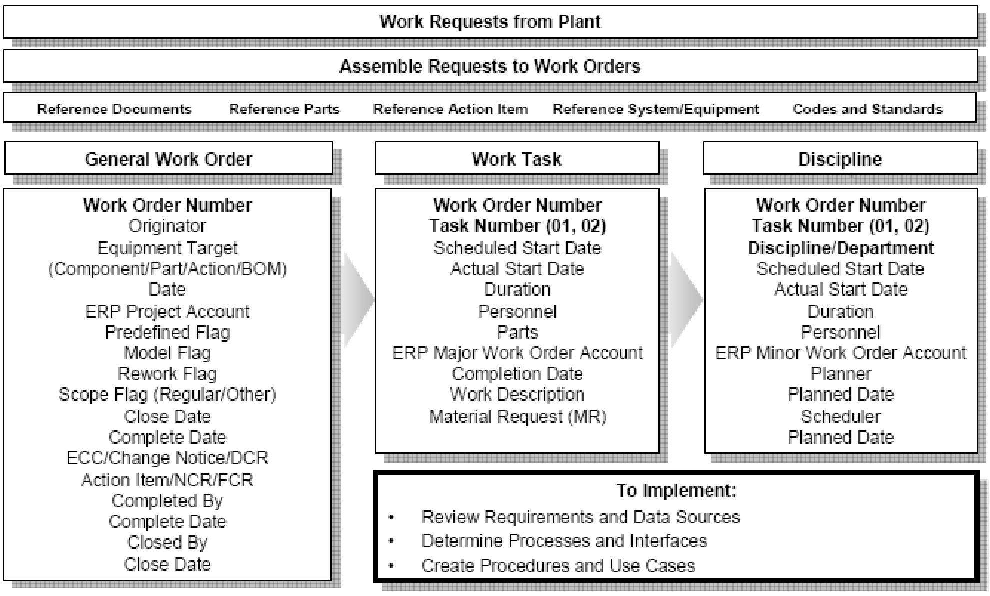


FIG. 15. Work management relationships and process

5.8.6. Materials catalog and basic inventory module

This module establishes a catalog or vendor stock code list, material requests from work orders, UTC and installation history.

Owner:

nuclear power plant materials manager or maintenance department manager

Responsible for

Updating data through only one of the following:

- Bills of material
- Work order material request
- Material return

The maintenance department manager is responsible for:

- Assuring the catalog is correct in terms of stock codes and qualification status
- Reviewing inventory and stock levels based upon past and future maintenance.
- Catalog content and accuracy
- Inventory and warehouse stock, counts, etc.
- Vendor materials data

Figure 16 illustrates the materials and parts processes from a work order perspective, which is the most likely source of a potential CM or design basis impact from parts replacement. Parts are selected for the work and ordered through the material request (MR). If a substitute part is required due to qualification or stock reasons, the approved model list (AML) and bill of materials maintained by the nuclear power plant for the component is used to select the appropriate part for installation. In cases where a suitable part is indicated to be no longer available, the procurement engineering process provides the mechanism for finding a substitute.

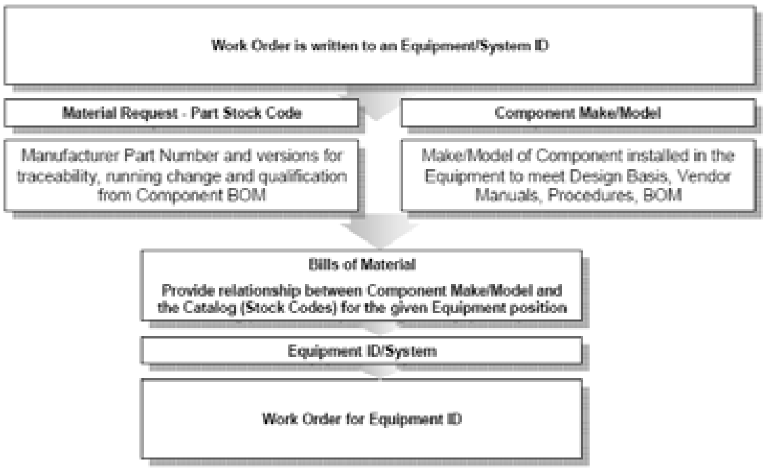


FIG. 16. Materials and parts processes

Figure 17 describes the relationship of stock parts, bills of material, component make and model, serialized items and finally, equipment items. The origin and relationship of the design basis information from plant designer and component manufacturer is shown also. Establishing the suitability of a manufacturer's component or part to be a particular equipment item in the nuclear power plant that satisfies the design basis is the main object of procurement engineering. The Equipment items (far left side) as determined from the design basis are filled with one (or more) interchangeable models of component from one or more manufacturer. These components have manufacturer specifications which must meet or exceed the design requirements to perform the equipment's normal and safety design basis functions as required. Within the materials catalog are contained not only the component stock information, but data for the parts and subassemblies that make up a given component. Many of these parts or assemblies have their own manufacturer specifications, qualifications and other requirements. A list of the type and quantity of each spare part utilized for a particular model of component is called a BOM. (In some nuclear power plant's, the entire stock inventory system is also referred to as 'Bill of Material System').

The purpose of establishing these relationships is to identify, track and manage the configuration of parts and components when installed in the nuclear power plant to perform one or more design basis functions. Individual parts, assemblies and components each affect the ability of the equipment as a whole to perform its intended functions, and must be accounted through the configuration management process, particularly in case of component failure and maintenance issues.

6. CM SOFTWARE DEVELOPMENT PROCESS

6.1. Design overview

The overall CM IT software design process is similar to the design of any enterprise technology solution, with the additional effort of including nuclear business practices, regulatory and licence requirements, and power plant and utility work culture.

Figure 18 describes the overall process map for design, development and deployment of a complex information technology solution such as an nuclear power plant enterprise configuration management system. Decisions for architecture, hardware platform, functionality, user base, software solution, deployment topology and legacy data migration are considered to select technologies and develop the system, as shown in Figure 19.

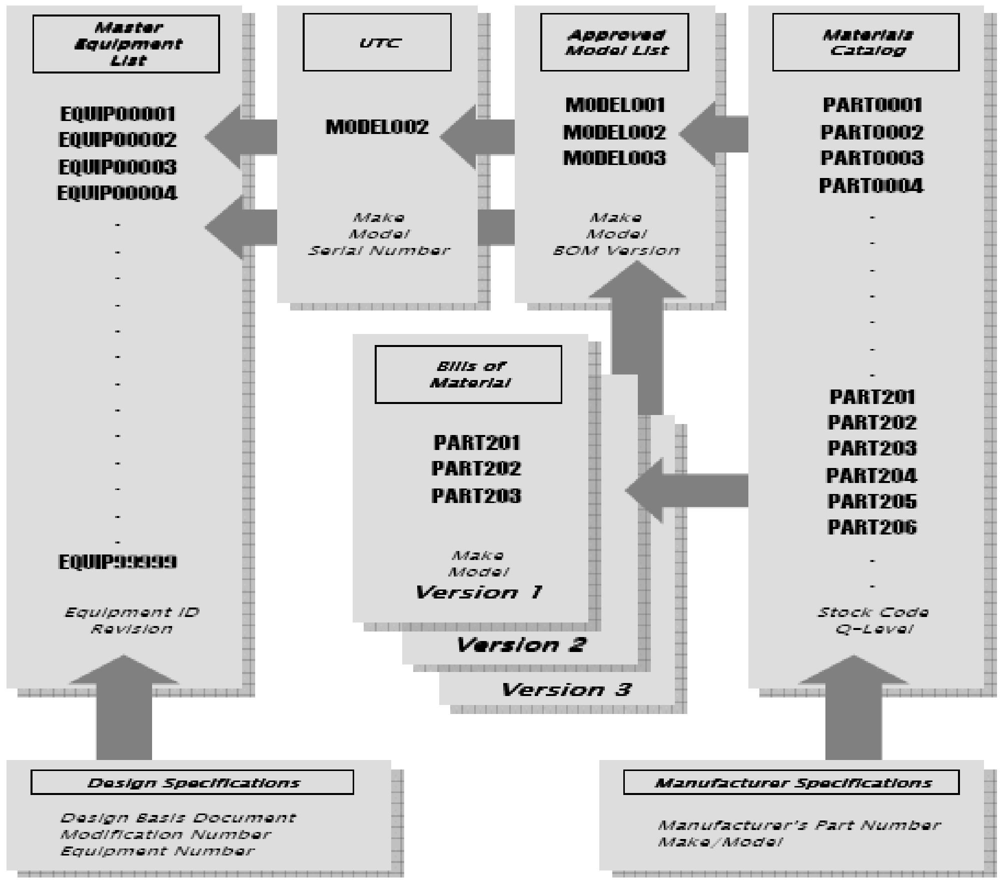


FIG.17. Sample design considerations for equipment and parts cycle

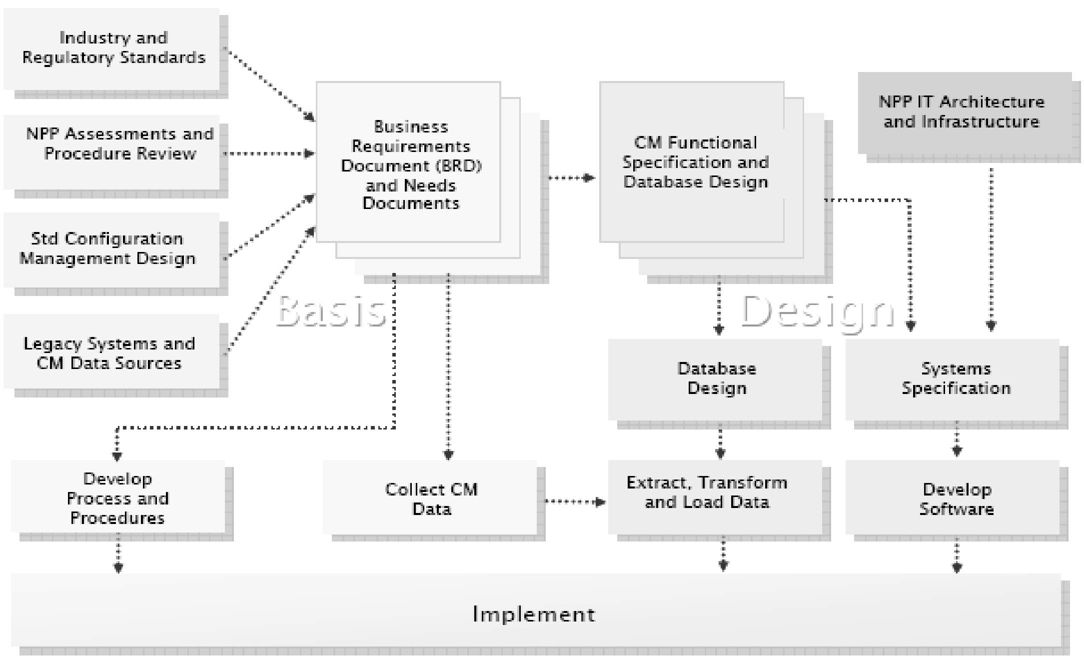


FIG.18. System design 'roadmap' and development hierarchy

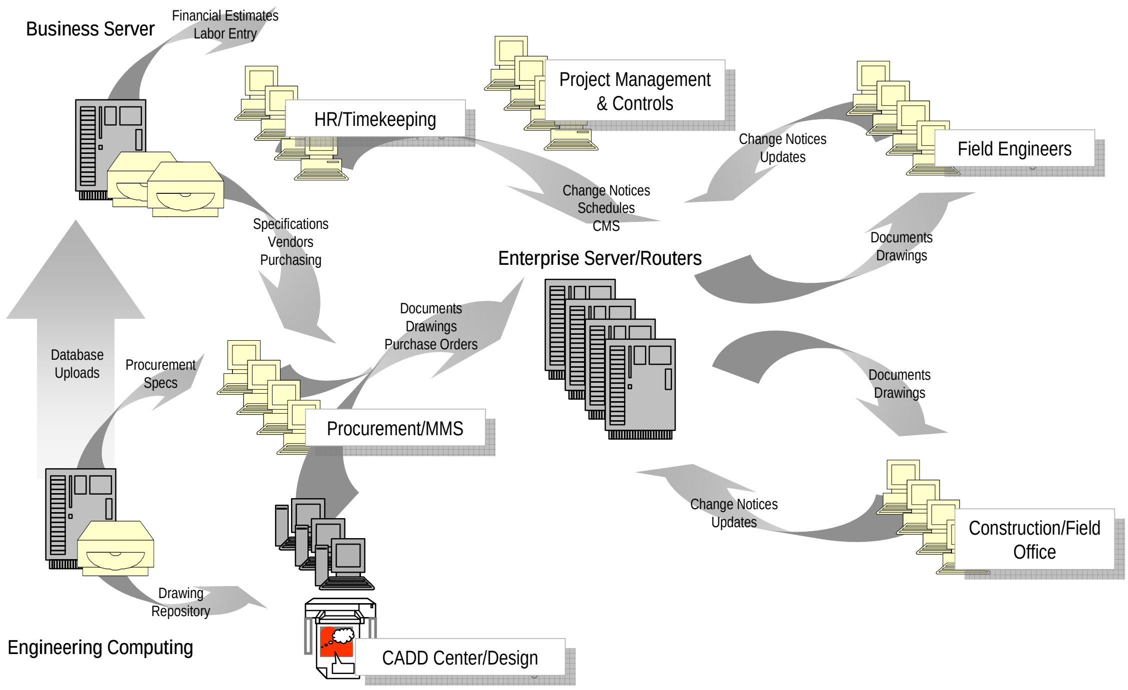


FIG. 19. Sample topology and infrastructure for an nuclear power plant enterprise configuration management technology solution

The development and implementation of a configuration management technology solution generally follow this path. See Appendix V for checklists for each of the following steps:

— Requirements & business process improvement
— Business model, rules for functional specification
— Data sources, acquisition, and migration
— Information technology infrastructure
— Industry standards
— Legacy systems and data
— User interface – screens and logic
— Interfaces and cross-references
— System specification, programming and testing.

6.2. Software testing

After development, software is tested in several regimes: Unit testing, system testing, and user testing. If changes were made to existing software in a production environment, regression testing to ensure the changes do not impact other applications will be conducted also.

Unit testing – the software programme is tested in an isolated computer memory region, with no interfaces to external memory, live data or other applications. Test data and test scripts are created to ensure that features of the programme are fully utilized, and results are observed. Unit testing is performed first to get the best opportunity to observe and isolate faults or errors in the programme. Testing and results are documented in on test results form, which becomes a permanent part of the software QA record of the solution.

System testing – the software programme is installed in a test region prepared with other production programmes that will interface or be impacted by the application. The test data and scripts are repeated, and results documented as in user testing. Occasionally, adjustments and additional programme code may need to be developed.

User testing – similar to system testing, except live product users selected from the nuclear power plant are utilized as testers. Instead of test scripts, the users are encouraged to create their own scenarios and test regimes, to ensure that complete functionality has been included and no software ‘bugs’ appear.

6.3. Documentation

In addition to the documentation required to support the quality assurance and software configuration management requirements, such as specifications, business process rules and test scripts, deployment of the enterprise CM solution will require user manuals and training materials.

6.4. User manual and guide

A user manual and guide should be prepared for users to refer to for functionality, features and operating the system. The user manual should also serve as a design document to complement the functional specification for software functions and features. User manuals should be relatively simple and straight-forward.

6.5. Training

A training programme must be implemented to coincide with the deployment of the IT solution. Training may be oriented to all users, and may be implemented in a ‘train the trainer’ regime, where key personnel with extended IT and subject matter knowledge may be trained formally, then return to their nuclear power plant organization to conduct training focused on their respective business areas.

6.6. Reporting and queries

An enterprise data management solution has three basic purposes:

1. Data repository
2. Control of business processes and incorporation of business rules
3. Data retrieval (reports and queries)

Business processes and rules usually receive the bulk of the attention from software designers, with data being viewed as an effluent or media to be acted upon by the business processes and subject to the business rules of the enterprise, and more often than not, presumed to already exist in a useable form. At any given moment, a snapshot of static data would reveal changes to the database in the form of new records, removed records, or changes to data within existing records, reflecting the action of the business processes.

Generally, when designers conduct design sessions with users and create the various flowcharts used to represent and translate the enterprises business processes into a model used to develop the IT solution, relatively little time is spent on data requirements, and even less on reporting and query requirements. Data requirements are expected to 'fall out' of the business processes more or less by themselves, while reports are postponed for late in the development process. *However, the primary purpose of the CM IT solution is decision support. The goal of loading data, maintaining its integrity, and manipulating it with processes reflecting business functions and rules is to produce reports and answer queries.*

Enterprise software forms design and user interfaces are usually designed with a priority for data entry, not data retrieval or query. However, the design that makes data entry efficient may not best support the subsequent production of useful information. In addition, data relationships (such as compound keys and data cardinality) required to fully understand how to write the best query to answer the question will likely not be apparent from study of the screen forms.

Most data entry is performed through bulk load, either from legacy data that has been filtered and reformatted as needed to be compatible with the new data repository, or from an external source such as a front-end data collection point.

Data warehousing

Data warehousing is the concept of collecting key CM data into a common location to be utilized for data queries and decision support. The data Warehouse may not contain all data from enterprise IT sources, but will contain data elements that are considered important to query and information retrieval. This subset helps users focus on query results and reduces the data that must be reviewed for queries.

There are four 'layers' to a data warehouse solution:

(1) In the *data repository layer*, raw data is entered and validated. All data dictionary targets are utilized.

(2) The *business rule and controls layer* determines validation, data relationships and some co-defined data (e.g. complex codes) for the data dictionary.

(3) The *PLM/CM layer* controls the process of ensuring that all users, organizations, business processes and data affected by the data entered are notified and accept or modify the data, maintaining and managing configuration during the process.

(4) *Data warehousing* contains selected enterprise data, as well as the 'cut' and 'view' properties of selected data elements to produce 'question-and answer'- type data queries based upon nonlinear formula (for relational database models, these are classified as 2nd- and 3rd-order normal-form queries). Data warehousing is effective for:

  — Linear and non-linear data integrals, such as consumption over time, hours accumulated per fixed variable, etc. This type of facility supports a milestone-based progress reporting environment by solving materials and manpower quantity 'expenditure-to-date' or 'for-period' queries.

  — Taking advantage of construction and design data that has stable, normal-form key relationships to produce data 'views' or 'slices' provide flexible, context-sensitive queries and reports.

Delivery

The data warehouse/knowledge base relies strongly upon systems integration and an enterprise data model. The design engineering area demonstrates a particularly strong impact from CADD sources, raw design data repositories, data and specification sheets, and niche data sources from industry and trade groups, which produce basic nuclear power plant documents and quality records. The data repository and post-CAD drawing data are of particular interest to design and construction organizations, which follow a cohesive data- and document-creation and distribution taxonomy.

Data warehouse/knowledge base for plant construction phases

The data warehouse provides a ‘knowledge-base’ for such queries as equipment-component- and labor-based accounting of proposed, scheduled and actual cost, expenditures and variances in construction. This include EPC, vendor and subcontractor experience and input through the PLM engine, and forms a complete picture of item cost, installation, configuration and performance.

In the procurement example in Figure 20 and Figure 21, data and documents produced in the nuclear power plant construction process are managed in a common data warehouse, to support historical and ‘what-if?’ type information queries.

Individual reports tailored to specific analysis or vendor bid requirements would be available through the query facility. The format and content of these reports can, for the most part, be anticipated prior to requirements for nuclear power plant construction.

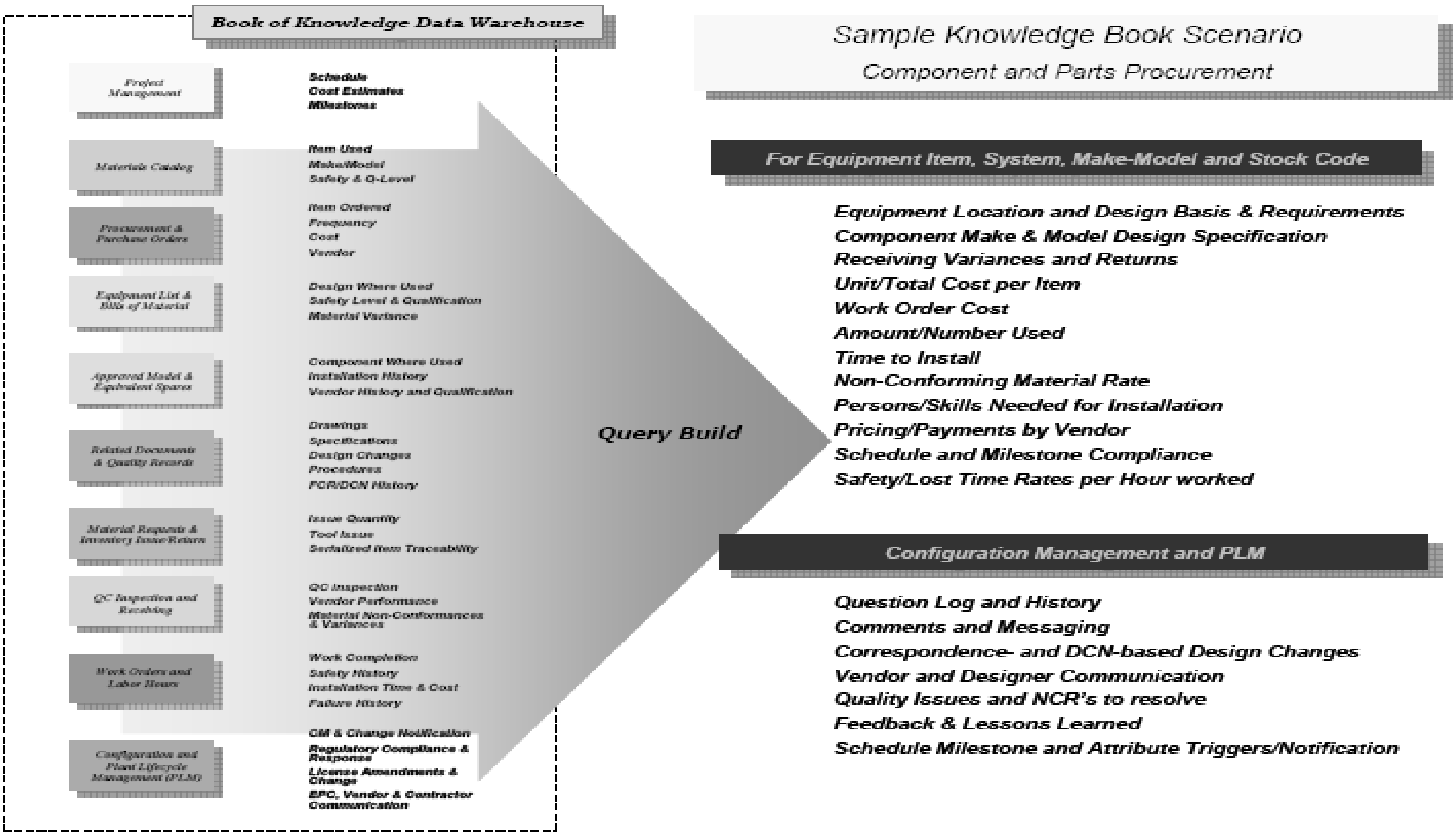


FIG. 20. Sample warehouse query for parts procurement questions

Utilization History – Valves Under 3.5”

Catalog ID	Make & Model	Avg Lead Time (Days)	Avg Stock	Control Document	Price per Unit	Total Cost	Avg Install Time	Typical NCR or Variance	DCN’s issued
2235667	Copes-Vulcan 2860	14	20	DWG-184	2600	2600	5 Hrs	None	2
2277679	Copes-Vulcan 2862	14	20	DWG-184	2600	2600	6 Hrs	None	1
2235457	Crosby [illegible]	30	6	DWG-2230	24000	24000	20 Hrs	None	4
								[illegible]	2

FIG. 21. Sample procurement-based report model by stock code, make model and where-used

6.7. Project management

Appendix V describes a sample project management plan, including analysis, development or purchase of an IT solution product, deployment schedule and deliverables checklist. The example includes estimates of resources and work hours which, when added to software licence and deployment costs, may be used to estimate the total effort and relative expense of the various approaches to development of and IT CM solution.

Added to this is the concept of TCO, which is calculated through the sum of initial deployment costs as well as recurring maintenance and updates. Like other economics, each solution can offer different its own combination of fixed and variable costs that may make, for example, the highest up-front cost result in lowest cost over service life of the solution through reduced maintenance and licence fees.

7. CONCLUSIONS

As nuclear power plant operators undertook design basis reconstitution efforts, they began to realize that the design basis is a foundation for configuration management. This realization was made evident in the magnitude of the problems that were being observed. This experience also raised serious questions about how the information being developed to produce the design basis documents would be kept up to date in the future.

The plant operators tried a variety of methodologies and mechanisms to reconstitute design bases with varying degrees of success. One factor that quickly emerged was the recognition that reconstitution of the design bases for an operating facility could be very expensive. The hardware and software technology available to today’s nuclear operators is far more powerful than ever before and still evolving. It is prudent for the nuclear operator to properly invest in information technology. Investment in appropriate IT can pay multiple dividends to the operator.

The modification processes used at the nuclear power utilities should be well structured and documented. They should include several assessments and reviews to ensure that possible problems are identified and corrected as early as possible in the process. They should have proper controls to ensure that configuration management documents such as system and topical descriptions can properly be updated in a timely manner.

Many nuclear facilities, especially the older ones, were constructed with documentation that does not fit present day needs. In many cases, the documentation is paper-oriented or on microfilm that does not readily lend itself to electronic conversion. Electronic conversion of film or paper documents greatly assists in an overall configuration management strategy. The hardware and software technology available today provides the capability for electronic recording, storage, retrieval, processing, and distribution of information related to the facility.

Configuration management processes must ensure that the construction, operation, maintenance and testing of the physical facility are in accordance with the design requirements as expressed in the design documents. A process to reconstitute the design basis is likely to be ineffective if configuration management controls are not in place. Programmes also need to be in place to maintain the configuration management after the reconstitution is complete.

The right IT solution for configuration management and asset management for an nuclear power plant depends upon a number of factors, including the nuclear power plant culture, budget, target technology, and the nuclear power plant owner/operator's standards, requirements and limitations for its generating fleet. The 'Buy-vs.-Build' decision will be the most challenging to resolve, because of the often conflicting benefits and risks to commence an in-house project as opposed to purchasing software. These conflicting factors are price vs. risk: in-house solutions cost less, but depend upon the supply of IT talent and risk of project cancellation or failure due to budget, management changes, or organizational inertia. Purchased solutions usually cost more up front, but can be consigned to a contractual obligation to a third party to help ensure completion, and will rely much less on the continual application of nuclear power plant resources for success.

As a result, there is no 'correct' answer for nuclear power plants in general, only what's right for each plant. Those nuclear power plants looking at commercial solutions will face various sales approaches, but most will repeat a common theme of 'one size fits all', and this is where many commercial vendors fail. They make too many assumptions about not only the ability of their product to satisfy the nuclear power plant's requirements, but also make too many assumptions about their own product's capabilities and ability to fit into the particular nuclear power plant's overall IT resources and needs.

Large, commercial mainframe-computer-based enterprise MRO and ERP IT systems are not only out of financial reach for many nuclear power plants, but in fact, would not be the correct CM solution even if cost were not an issue. The complexity, size and work culture adjustments needed to fit a solution like these into everyday business, for many nuclear power plants, would be counter-productive and could trigger project rejection and failure.

The important thing for nuclear power plant IT solutions is to ensure they are 'right-sized,' have the essential functionality needed to update and maintain the design basis and plant configuration management, and can be integrated into the nuclear power plant work culture and business processes without excessively long deployment, implementation and training cycles to make the solution viable. Strong user involvement and identification of key 'stakeholders' in the project will help ensure success and longevity to the enterprise software solution.

A design basis document library that includes system and topical descriptions is a major step forward in effective configuration management. It is incumbent upon the nuclear facility operator to establish and maintain a system and topical description update programme that is linked to all processes that can change the facility configuration.

The design and implementation of information technology software or system for electronic document management should be based on an integrated approach related to the whole facility. A modification process based upon an IT system and integrated with the design document library simplifies the document update process.

Selection of software for the design basis document library must not only consider the present integrated needs of the facility, but it must also account for future expansion. A review of the future needs of the facility as well as the current needs is prudent. In addition, the software selected should not only fit the nuclear power plant target IT architecture and be economical, but should fulfil the functional requirements for nuclear power plant safety and operation.

Knowledge retention is recognized as essential to continued safe and economic operation of the facility. This is especially important for those plants that have an aging work force. Maintaining a detailed set of system and topical descriptions and a complete design document library can assist in maintaining knowledge retention.

The efficiency of configuration management processes must be continuously assessed and updated. This can be accomplished through self-assessments, peer reviews, and reviews of the corrective action database. Changes and updates to the configuration management process should be disseminated to facility staff via communication documents including notices and news letters.

When the nuclear power plant considers an IT solution for CM and asset management, two prerequisites can be identified. First, the design basis for the nuclear power plant must be up-to-date, the documents and data to support it must be created and accessible through a document management technology, and a methodology for maintaining the nuclear power plant design basis must be in place. Second, sufficient IT resources and infrastructure must exist at the nuclear power plant to support the system and technology desired.

This does not mean the nuclear power plant needs to spend a great deal of money on IT facilities and infrastructure, but rather, the software solution should match the available processors, storage and network available at the nuclear power plant, or within realistic plant budgeting. Budget and cost must be matched against the importance of design basis integrity, and the savings to be realized from deployment of an overall nuclear power plant business process technology solution.

Different nuclear power plant cultures and budgets will support different CM IT solutions, but there is no reason that cost should impact functionality and completeness. The design and specification of a comprehensive IT solution is not primarily a matter of cost or expense, but rather research and understanding the goals and objectives of developing such a system. This report is one such resource which may be used for this purpose.

The best approach for nuclear power plants to select and deploy an enterprise CM and design basis IT strategy is to concentrate on functionality, business processes and key users/stakeholders that will ensure the success of the software, as well as ensure the maintenance of an accurate, documented and verifiable nuclear power plant DB.

APPENDIX I.   IT PROCESS AND SAMPLE ARCHITECTURE

The design of the configuration management IT solution revolves around design concepts applied to a solution for nuclear power plant business processes and rules. Figure I-1 illustrates some of the basic tools utilized in the design of an IT solution for nuclear power plant configuration management.

The entity relationship diagram (ERD) is used as a modelling tool for the basic functionality of the CM solution, and to help organize business rules along the lines of workflow and work functions. While not always strictly viewed as ‘modules’, the concept can be applied in the early design phases to help align the goals of the software solution with business processes, procedures and personnel.

The ERD also assists in recognizing and designing data relationships. Traditional views of relational database rules and concepts have been augmented by extensible markup language (XML) and other ‘open source’ data modelling designs that support the ways data are utilized in a flexible, PLM-oriented environment. However, the basic concepts of normal-form data relationships can be applied to modern database technologies and taxonomies.

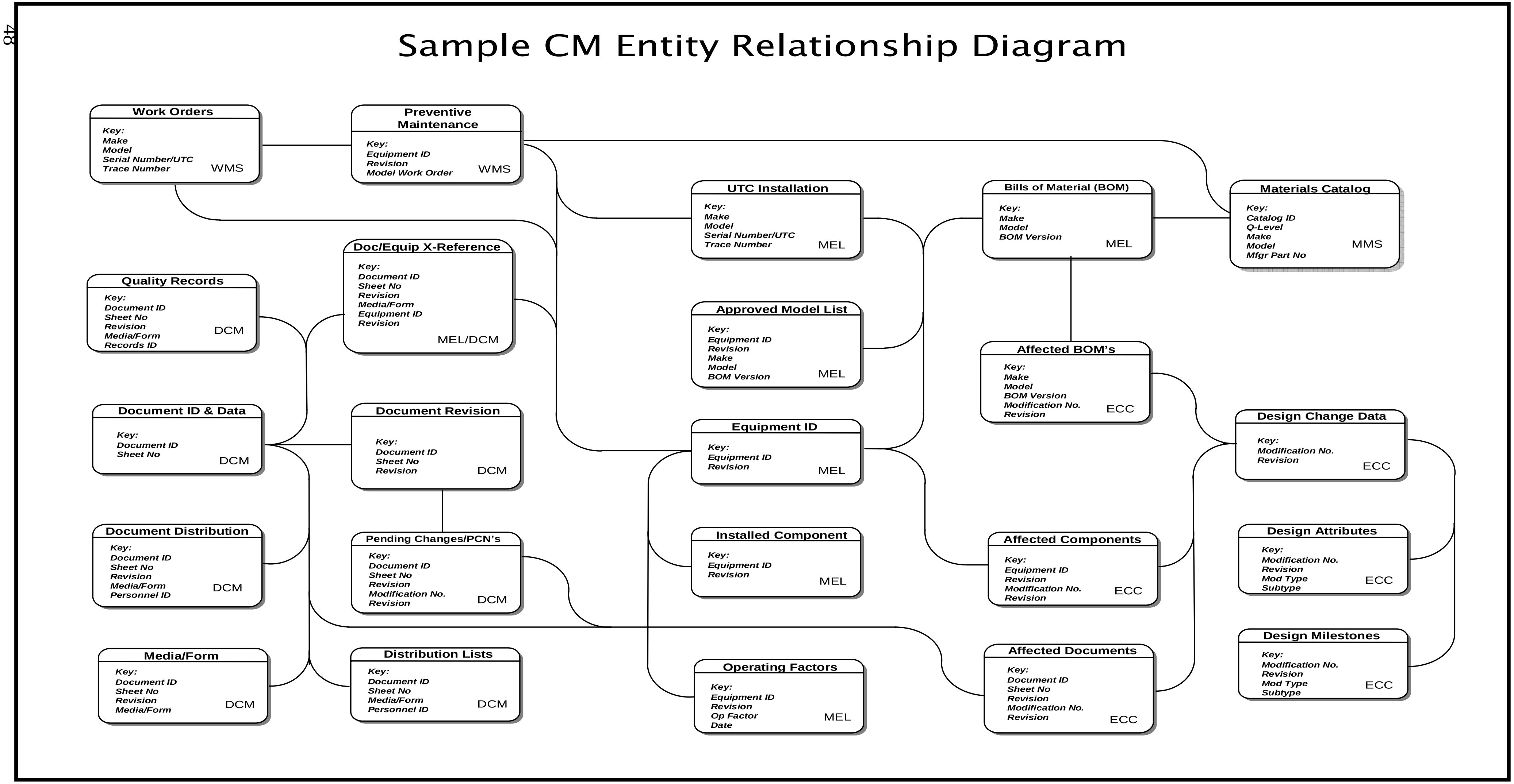


FIG. 22. Example of IT architecture for nuclear power plant configuration management.

APPENDIX II. DATA SOURCES AND ELECTRONIC ACQUISITION

II.1. Data sources and electronic acquisition

Nuclear power plants that did not start configuration management systems from the beginning of design and construction likely have a sizeable archive of legacy documents created prior to, and even during, commissioning and early operation. This will result in a large store of legacy documents and data containing design basis information. Depending upon the method for establishing (or re-establishing) the design basis, these documents may need to be scanned, digitized into computer-based files and reviewed by engineering for legacy data to be introduced to data collection systems for the configuration management system. These can include documents, drawings and data.

In addition, key nuclear power plant vendors will also be in custody of legacy design and procurement documents, drawings and data which should be delivered as part of the contract agreement with the vendor. The format, organization and delivery schedule of these documents should be included in contractual agreements for the designated work.

A sample process for collection, scanning and storing of legacy paper documents is described in Figure 23.

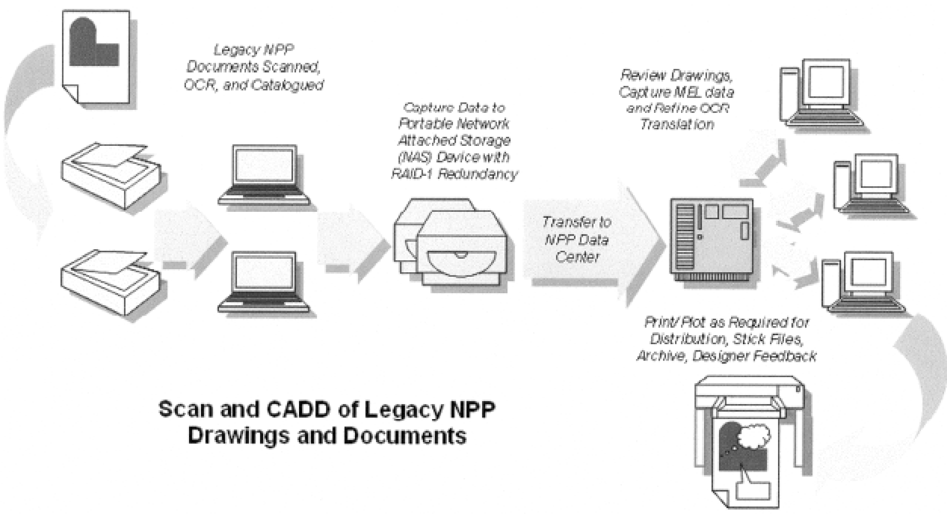


FIG 23. Legacy document scanning, and image and data capture

Those documents to be scanned and utilized as baseline design basis documents may be selected from all plant documents by the following criteria. By grading and scaling the task, the maximum number of relevant documents may be restored while not scanning and cataloguing all nuclear power plant documentation and quality records, which may number well over 1 million pages for a mature nuclear power plant.

II.2. Documents to collect as legacy design basis documents

Document Description	**Key CM Element**
As-built Drawings and Data Showing Plant Installation	Equipment ID

Contains Equipment ID Numbers and Static Data (Location, Train, Loop, etc)	Equipment ID
Relates Documents to an Equipment ID	Equipment ID
Determines Equipment-Component Relationships as a Basis for Parent-Child	Make/Model Equipment ID
Used to Determine an Equipment ID’s membership in a Determinant or Engineering Programme (i.e. EQ, Valve List, MOV, ASME XI ISI, etc.)	Equipment ID
Describes the Status of a Controlled Document or Quality Record	Document ID Record ID
Relates Components (Make/Model) or Parts to an Equipment ID	Equipment ID
Describes a Determination of Safety Status or Category	Equipment ID
Describes the DB for Equipment ID	Equipment ID Document ID
Identify Substitutions for Parts	Equipment ID Catalog ID/Q-Level
Describes Changes in Physical Plant Lineups, Relationships, or Equipment Associations	Equipment ID Modification ID
Introduces or Removes Equipment ID’s	Equipment ID Modification ID
Describes Calculations, Setpoints or other Parameters which are characteristic of the Equipment ID	Equipment ID
Identifies Location, Personnel and Schedule of Equipment ID Installation	Equipment ID Work Order
Identifies Traceable Parts	Catalog ID/Q-Level
Resolves Relationships between Parts, BOM, Q-Levels and Active/Passive Safety Application	Equipment ID Catalog ID/Q-Level
Identifies Timing and Whereabouts of Traceable Parts in Plant	Equipment ID Work Order
Relates Standards and Procedures to Equipment ID	Equipment ID Document ID
Relates Documents to Parts or Traceables	Catalog ID/Q-Level Document ID

Describes or Controls a Plant QA Programme	Equipment ID Document ID
Safety and Risk Assessments	Equipment ID

II.3. Data to collect as legacy design basis documents

Data is also a major component of the nuclear power plant design basis, and should be taken into account in a design reconstitution programme.

Engineering Documents/Manufacturer data

- Equipment ID's
- Document References
- DB References
- Equipment Air/Power Supplies
- Equipment Associations
- Modification Package Numbers
- Modification Dates (As-Designed, As-Built, Commissioning, AFS)
- For Construction Plant, Turnover/Installation package Numbers (or System Code and Date)
- Approved Models (Make/Model to Equipment ID)
- Equipment Static (Nameplate) data
- Equipment Determinants
- Equipment Tag Numbers
- Permits and Regulations (Equipment ID)

Engineering Support/Procurement

- Document-Equipment Cross-Reference
- Document Number, Sheet, Revision
- Records Numbers
- Equipment Revision
- Creation Date
- Turnover Date
- Approval Date
- Distribution Lists
- Parts installed in Component/Equipment Locations (As-Built BOM)
- Replacements and Substitutions (Catalog ID/BOM to Equipment ID)
- Equivalency Evaluations (Catalog ID to Catalog ID)
- Commercial Grade Dedication Lists (Catalog ID to Catalog ID)
- Purchasing Standard Descriptions (to Catalog ID)
- UTC Locations

Work Orders

- Installed Date
- Commissioning Date (Equipment Revision)
- Removal Date (Equipment Revision)
- Parts/Catalog ID
- Substitution of Parts (Catalog ID)
- Traceability Data: Serial Numbers, Lots, Heats, UTC's
- Personnel Working And Inspecting/Reviewing

Services and GSA’s (with work orders)
UTC Locations
List Pre-defined/Preventative/Predictive Maintenance (Equipment ID)
Document ID to Work Order/Predefined
Job Variances (Equipment ID, Catalog ID)
Installed Date
Commissioning Date (Equipment Revision)
Removal Date (Equipment Revision)
Parts/Catalog ID
Substitution of Parts (Catalog ID)
Traceability Data: Serial Numbers, Lots, Heats, UTC’s
Personnel Working And Inspecting/Reviewing
Services and GSA’s (with work orders)
UTC Locations
List Pre-defined/Preventative/Predictive Maintenance (Equipment ID)
Document ID to Work Order/Predefined
Job Variances (Equipment ID, Catalog ID)

Licensing/Analysis
- Equipment ID’s
- Determinants
- Technical Specifications (by Equipment ID or System)
- DB References

Training
- Simulator Design Input (Equipment ID’s)
- Training Personnel Lists

Information Technology
- Programme or Application ID
- Version Numbers
- Replacement History

Measurement & Test Equipment (M&TE)
- Calibration Items (Equipment ID)

APPENDIX III. AN EXAMPLE ON VALIDATION OF THE DB AND ITS INCORPORATION IN THE IT SOLUTION

In order to ensure that the CM process is on a solid basis, nuclear facility personnel may embark on a design basis reconstitution programme. This programme would perform the one-time task of identifying, retrieving, extracting, evaluating, verifying, validating, and regenerating missing critical design requirements and basis. This design reconstitution encompasses the functions of developing associated programme plans and procedures; identifying and retrieving design information from identified source documents; evaluating, verifying, and validating the design information; resolving discrepancies; regenerating missing critical design information; and developing System and Topical Descriptions. Once the reconstitution effort is complete, an effective CM programme will ensure that the design and licensing basis is maintained.

III.1. Verification of plant configuration

Verification of the plant physical configuration should be conducted to establish confidence in the documentation. This may take a graded approach with the verification of risk-significant systems taking precedence. Additional systems of lesser importance should be included as resources allow. At a minimum, a sampling of the configuration of the less significant systems needs to be conducted to ensure the configuration is maintained correctly across the full spectrum of the facility systems. Facility personnel may need to conduct special reviews on an as-needed basis, when abnormal events or transients occur that affect safety systems resulting in a lack of confidence in the facility configuration.

These physical configuration verifications may be performed on a sample basis, with the sample providing a representative cross-section of component types within the system being assessed. The sample should be large enough to ensure that a statistically significant portion of the system and its components are chosen.

Two common types of physical configuration verifications are facility walk-downs and resolution of configuration and documentation discrepancies. While the processes of walk-downs and resolution of configuration and documentation discrepancies have significant overlap, the distinction between them needs to be understood. One distinction is based on the result of these processes. A product of the walk-down process is a set of marked-up documents that reflect the actual physical configuration and identify discrepancies with the currently approved facility documentation. A product of the resolution of configuration and documentation discrepancies are the creation of ‘as-built documents’ that have been field-verified and design-verified.

For the design reconstitution programme, the process of checking that the retrieved design information has been completely and accurately translated from the source documents is essential.

III.2. Licensing bases identification

The licensing bases can be considered as the set of documents and regulatory commitments, including the SAR, operating licence, and correspondence that form the basis for the plant licence.

With the exception of the SAR and the operating licence (described below), elements of the licensing basis need to be extracted from existing correspondence with the regulator to establish two types of licensing basis; document compliance and commitments. In the document compliance review, references to selected regulatory guidance documents should be reviewed and a position developed to document the specific commitments to compliance. In the licensing commitment effort, any written commitments that are formally communicated to the licensing authority, and the method of incorporation into plant practices should be entered and into an established tracking system. The products of these efforts should be included in the development of a licensing basis database, fully text searchable, containing the attributes identified in the review. This database can be used during the course of the reconstitution effort and then maintained for life of the facility.

III.3. Validation of analyses and calculations

Having accurate and applicable calculations and analyses are at the core of an effective design basis and configuration management programme. A detailed process needs to be developed for identifying critical calculations in risk-significant systems and topics, identifying the extent of review of these calculations, and developing acceptance criteria to determine the need for calculation upgrade. The product of this effort would be the identification of the calculations requiring revision/reconstitution and the specific weaknesses in these existing calculations.

Following identification of the calculations required for review, a strategy must be developed to determine how to assess and evaluate the facility calculations. One strategy for performing this assessment is categorized below:

Obtain and review the existing or draft system and topical descriptions and topical reports, and summarize the design bases and safety functions in a tabular format. For each safety function (e.g. a minimum flow requirement), identify the associated attributes to achieve the function (e.g. adequate NPSH, vortex avoidance, adequate strainer differential pressure.). A table of the safety functions and associated attributes for each system will be prepared. This table will include provision for identification of the current calculation of record that supports the safety function and attributes, as well as the design margin.

Associated system attributes for the safety functions will also be identified in the table described above. For example, room cooler design performance may be required for the component to function as intended.

The facility risk assessments will be consulted to identify high risk components with these critical safety systems and topical areas. Safety functions for these items and associated attributes will be added to the table if not already identified from the above review.

Obtain and review the current operating licence and emergency operating procedures to identify bases and set-points, and include these items in the system table.

Develop a methodology for the review of the calculations. Essential elements of the methodology will include:

- Completion of the tables prepared as described above to identify specific calculations to be reviewed
- Considerations of the critical items of a calculation; scope, approach, methodology, design inputs, assumptions, and conclusions
- Consideration of the significance of any outstanding items in the corrective action system against the calculation, which should include issues identified during previous inspections and assessments
- Lessons learned from other plant calculation reconstitution efforts.

Define criteria to determine if the calculation being reviewed should be revised or reconstituted. Important elements of the acceptance criteria include:

- Assumptions used in the calculations, whether they have been validated, and the basesfor the assumptions.
- Critical operator actions assumed in the analysis will be given particular attention
- General technical rigor of the calculation and conformance with appropriate industry standards
- Whether calculation reviews and validation have been correctly performed in accordance with facility procedures
- Number and severity of outstanding corrective action items against the calculation
- Whether the conclusions of the calculation support the purpose.

It is prudent to develop a pilot using a small sampling of calculations to implement the above process to assess its adequacy, and revise the process as appropriate. Once the pilot is completed, it can be reviewed and corrections made prior to implementing the full project.

III.4. Design bases identification

Since the design bases consist of information that identifies specific functions to be performed by a structure, system, or component of a facility and the specific values or ranges of values chosen for controlling parameters as reference bounds for design, they can be extracted from the facility calculations and other documents identified in the system and topical descriptions. Table 5 provides a sample design basis document and organization sources for a US nuclear power plant. The requirements in the 'mandate' column will vary depending on the regulatory framework under which the construction and operation of the nuclear power plant is authorized.

Table 5. Sample design basis documentation and sources

Type of Document	Mandate	Source	Review	Approval	Distribution
SAR	10 CFR 50.71	Licensor	NPP	Regulator	NPP Regulator
Technical Specification/System Description	ANSI N45.2.9	NSSS Vendor	NPP NSSS Vendor	NPP	NPP
Vendor Manuals	ANSI N45.2.9	Vendor	NPP Vendor	Vendor	NPP
Systems Design Criteria	ANSI N45.2.9	NSSS Vendor	NPP NSSS Vendor	NPP NSSS Vendor	NPP
Engineering Design Criteria	ANSI N45.2.9	NSSS Vendor	NPP NSSS Vendor	NPP NSSS Vendor	NPP
Design Basis Conceptual Analysis	ANSI N45.2.9	NSSS Vendor	NSSS Vendor	NSSS Vendor	NPP
A/E Design Specifications	ANSI N45.2.9	A/E Designer	NPP A/E Designer	NPP A/E Designer	NPP
Procurement Specifications	ANSI N45.2.9	Manufacturer Engineering	Manufacturer Engineering	NPP	NPP
Industry and Regulatory Standards	ANSI N45.2.9	Subscription	NPP	N/A	NPP
Operating Technical Specifications	10 CFR 50.71	NSSS Vendor, Licensor	NPP Licensor	Licensor	NPP Licensor

Well-designed STD contains a collection of the necessary information in one location as well as the roadmap to the source documents and calculations. Inherent in STDs are the design basis requirements imposed on a system by analyses and calculations. The design basis requirements can be represented by functional values (e.g. flow, pressure, voltage, temperature, etc.) in the STD. These values may be constraints derived from generally accepted state-of-the-art practices for achieving functional goals, or requirements derived from analysis (based on calculation and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals.

Upon reviewing these calculations, the bases for design requirements can be identified, documented, and maintained to the extent and level appropriate to the nuclear facility's mission, life cycle stage and other relevant factors. A technical review should be performed to determine the adequacy of the design basis. If the basis is not fully documented, or not complete, it may be updated to the extent required considering the facility life cycle, the cost of reconstituting the information, and the need for the information. The basis for new or modified design requirements can be established and documented as these requirements are developed.

The appropriate location for this documentation is the STD. The review of the STD should be included in the modification review process. This can include determination of the design basis of the portion of the facility being modified to determine that the original design bases are not violated by the modification.

III.5. Identification of gaps between safety analysis report and plant

The primary goal of the SAR gap review is to confirm that the design and operation of the facility is in full compliance with its current licensing bases, to resolve any inconsistencies in a timely and comprehensive manner, and to maintain the integrity of the current licensing bases as change occurs in the future. Implementing timely corrective action for any inconsistencies identified is an integral part of the programme.

The review also determines whether there are unreviewed safety questions that have not been previously identified and addressed. The programme should be divided into two phases: In the first phase, efforts are directed at validating information in the SAR, identifying and correcting inaccurate or incomplete information, and removing inappropriate information. In the second phase, the focus is on enhancing and improving the document to better reflect the current licensing basis, and in revising the SAR format and content to better support an operating nuclear facility.

The basic methodology for achieving the programme's goals is to conduct a rigorous comparison of the facility design bases and operating practices against information in the current licensing basis. That review, for the most part, is conducted as part of the design and licensing bases integrated reviews.

In general, the information necessary to support the review is obtained from three primary sources as documented in the STD: system, plant and accident analyses; station operating and administrative policies, programmes, and procedures for operating information; and the SAR and other correspondence with the regulator for current licensing bases information.

Using the corrective action programme is an integral part of the review. Detailed criteria and guidance needs to be developed and used in the SAR gap analysis to ensure the appropriate disposition of those SAR-related discrepancies on a timeframe consistent with their safety significance. An important aspect of the SAR review is that any inconsistency identified related to the SAR that meets the threshold for entry into the corrective action system is resolved within a timely manner using project resources. Also, criteria and guidance are established and used to ensure that any previously unidentified unreviewed safety questions are discovered during the review process.

As stated above, SAR improvement activities that do not directly support validating the current SAR content are addressed separately under the second portion of the SAR review and improvement process. Activities under the second phase include an assessment of the various ways in which the SAR is used to support a nuclear facility, the development of detailed SAR format and content guidance to support those uses, and the implementation of various format and content enhancements. It is envisioned that efforts within the second part of the programme include plant-specific enhancements to the SAR to make it more accurate and better reflect the configuration of the facility.

In order to best accomplish the SAR review, a database containing all SAR statements must be created. Review teams composed of individuals with expertise specific to the SAR sections to be reviewed are created. For the SAR validation and review, team members search the SAR for sections which relate to the system or topic under review. The resulting sections are screened and separated (segmented) into individual requirements. These requirements are single sentences or several sentences which relate to the same topic or requirement that are typically validated or certified by the same source document. These requirements are given a unique identifier and entered into the database. Different elements of this review include:

- Different teams comprising of team leaders, licensing engineers and discipline engineers are formed to concurrently review the SAR
- Segmented SAR requirements are confirmed to be accurately transcribed from the SAR into the database by team members at the beginning of team activities.
- The team lead characterizes each SAR requirement by assigning a preferred method of validation. Validation types are consistent with the level and importance of the SAR statement. Different types of validation include the use of source documents such as calculations and analyses, and implementing documents such as procedures and certification. Where the information is obvious, common knowledge and no facility documents are available or required.
- When a team member finishes the validation review of a SAR requirement involving a key parameter or assumption, another search is conducted through the SAR using key words or parameters to identify other SAR requirements that are similar to check for consistency of SAR information. If another SAR requirement is identified that is not part of the current team scope, they notify the team lead. The SAR requirement may already be assigned for review by another team; however, it may be relocated to the scope of the ongoing team if deemed appropriate. When assigned to a different team, any validation information that supports the SAR requirement will be added to that SAR requirement validation summary field as information for subsequent use.

SAR content improvements may be incorporated consistent with a set of guidelines. A good example of guidelines used in the USA is contained in NEI 98-03, Revision 1, ‘Guidelines for Updating Final Safety Analysis Reports’. Items in this document include:

- Guidance for removing excessive detail; for example, SAR drawings that have no reference in the text are reviewed for inclusion in the SAR. If the drawing is to be included, it will be validated, otherwise it may be removed. Detailed drawings can be replaced with simplified schematics
- Guidance for referencing other documents in the SAR
- Guidance for removing unnecessary information that is obsolete, redundant, or commitments that are not integral to required SAR information.
- Guidance for reformatting select SAR information; for example, characterizing and identifying certain information as historical.

Creation of roadmaps for design and licensing basis There can be two types of documents in the design document library, those that are expected to be updated and those that are stand-alone. Examples of the types of document that are expected to be continuously updated during the life of the facility are the plant drawings and procedures. These documents may maintain the same document numbers but their revision numbers are continuously updated. A typical case of the stand-alone type of document would be correspondence with the regulator. These types of documents are not revised; they may be supplemented by additional stand-alone documents. The supplemental document would be expected to receive an individual docket number.

The STD should be created in software that supports the linking process. An example of software that does this well is the Adobe Acrobat© (‘pdf’) document format. Acrobat© documents can be created with the ability to create hotlinks to other documents in the design basis library. The repository for these documents may be in separate types of software servers. The links to the documents that are expected to be updated may be dynamic. The link pointer should be to the document location and not an electronic file. If the source document is revised, the link will point to the revised document. With STD that are properly maintained and updated, any changes to the source documents that affect the STD will be identified and appropriate STD change requests can be created. Links to documents that are not expected to be changed can be to the electronic file itself and need not be to a specific location.

The writer’s guide that controls the development of the STD and provides guidance on format and content should give source document linkage information. Typically, the STD will have a references section that provides the links to all external source files including documents such as the SAR and operating licence. Any links cited within the body of the STD will direct the user to the references section that contains the external links. In this manner, the user can view information on the document cited before being directed to the actual source file. Typically, the user can navigate from a section in the STD to a source file in two mouse clicks. If the roadmap information in the system and topical description is correctly created, the user will be directed to the needed file in an efficient and expeditious manner.

III.6. Update of deficient documents and the design document library

Most facilities have been designed without using a fully computerized design system. This is especially true of the older plants. Most of the older documents for these plants, including drawings, have been developed by hand, or by using software that is no longer in use, and cannot be translated to new software without a thorough verification. Even for plants designed with ‘computerized’ design systems, many of the vendor documents were not computerized, or the vendor software was not compatible with the facility software. Electronic support for the original computer system may not be provided by the supplier. After some modifications, the so called ‘archived’ original document systems, and even the originals kept by the supplier, are obsolete and can no longer be used because reproduction has become nearly, if not totally impossible. If reconstitution by electronic means is not possible for practical or economic reasons, reconstitution of the physical document is sometimes necessary. In that case the verification that the reconstituted document is identical with the original document has to be thoroughly performed.

Design documentation can be affected not only by design changes, but also by the evolutions of safety standards and by periodic safety re-evaluations or generic issue evaluations even if no physical modification is initiated. Every time a new document affecting the configuration documentation is written or modified, it is necessary to check to ensure that all documents which can be affected by the new document or new information are modified as appropriate.

A documentation management system that includes computerized links among documents can be a valuable tool in accomplishing this verification.

Another challenge to the reconstitution effort is the fact that older documents are typically hand-written and not generated by machine. This leads to the inability to perform Optical Character Recognition (OCR) and text searchable documents. An effort to create good metadata and searchable attributes for these documents may be in order as resources permit.

III.7. Creation of master equipment list

The MEL (MEL), also known as the material equipment list, contains information on the facility at the component level that relates the function of the component to the design basis.

In order to properly create the MEL, a review of the licensing basis, design basis, and regulatory commitments need to be performed. This effort can obviously take advantage of other efforts done during a reconstitution including system and topical description development and SAR validation. Commitment documentation needs to be gathered and assembled prior to the actual assembly of the list. This documentation will help define a strategic approach to issues. Inputs from the design basis documentation can be used as initial inputs. There needs to be close consistency between the system information presented in the system and topical description and the component information presented in the MEL.

III.8. Creation of data bases for information retention

Nuclear facilities contain a massive amount of documentation. As document software has evolved over the life of the facility, the electronic documentation may be constructed of different types and formats. A common format and relationship among these documents must be established. This can help comply with traceability requirements from the regulatory authorities as well as the needs of operation and maintenance. While the documentation of many older nuclear facilities is largely in paper form, it is advisable that at least the documents that undergo constant changes should be transformed in electronic database format.

The databases created to perform SAR review and the requirements imposed by the STD and design document library are good starting points for defining requirements to IT based databases servers and electronic formats. One main focus is the workflow of activities that necessitate and rationalize decisions. Documentation of the design phases should be put into a database of information that will constitute the backbone of a database system. The subsequent life cycle phases will use and refine this database so that design bases are constantly updated and well tracked.

The nuclear facility operators should be aware that hardware and software are rapidly evolving and quickly become obsolete. Some current document management systems do not separate the representation of the information and the way this information is implemented. For these types of systems, a common format should be considered for the archiving of documents. Such systems as ‘pdf’ for written documents and ‘tif’ for drawings should be considered.

III.9. Creation of processes to maintain CM

In order to ensure that the results of any reconstitution programme are properly maintained, the facility processes must be evaluated and refined to ensure that documents such as the STD and the SAR are appropriately updated. The root cause of departures from the SAR will need to be identified to ensure that the project's corrective actions are effective and comprehensive. Existing change processes should be reviewed to ensure the integrity of the design and licensing bases information is maintained. After the facility processes are updated, appropriate, process-oriented training for the facility staff will be implemented.

There are several tasks within the review and reconstitution process that have a direct impact on maintaining the integrity of the SAR and the licensing basis. Those tasks lend themselves to identifying the causal factors related to the departures from the SAR to create corrective actions that will ensure improvements in the quality of existing change processes. This can be accomplished by determining whether each change process has the appropriate attributes to ensure that planned changes occur in accordance with acceptable change processes. Once the corrective actions are completed the new change processes can be introduced to the facility staff via process-oriented training.

Both formal and informal change processes can exist at the nuclear facilities. Formal change processes can include corporate and plant policies, programmes, procedures, and other administrative controls. Informal processes include general work practices, memoranda, or unwritten rules. A review of the change mechanism can be performed to ensure that informal change processes are not used when design or licensing basis documents need to be changed. Special attention should be paid to subtle change drivers that have the potential to modify the current design and licensing bases through informal means.

Appropriate sensitivity by facility personnel in maintaining the integrity of the design and licensing basis is a critical factor in ensuring acceptable performance. Training requirements, in terms of existing processes or process enhancements, are assessed and appropriate training developed and implemented. The training also instils, or reinforces as necessary, a questioning attitude among facility personnel with respect to the SAR, the current licensing basis, and the potential for proposed changes to adversely impact the integrity of the current licensing basis. An effectiveness review can be done at a specified period after the training is complete to ensure that departures from the SAR and basis documents has been reduced or eliminated.

III.10. Case study – design basis reconstitution

In 1996 it became evident that one of the nuclear plants in the USA had an ineffective configuration management programme. That plant became subject to intense review by the US Nuclear Regulatory Commission (USNRC). That review determined that, among other things, some required plant calculations were inadequate, incomplete or nonexistent. Some of the safety margins at the plant were not adequate. It was also clear that the plant’s SAR had not been properly maintained.

In response to these issues, the USNRC embarked on an effort to determine the adequacy and availability of design basis information at all operating nuclear power plants in the USA. The result of this was a letter to all subject plants requiring them to affirm the adequacy and availability of design basis information and to verify the fidelity of their respective SARs.

One utility responded by committing to a programme to, among other things, complete the development of their system and topical descriptions, to review and validate their updated final SARs (UFSAR), create a design basis document (DBD) library system as a repository for their design and licensing basis information, and review the in-place processes to determine future improvements.

The utility started by creating a project plan and developing special procedures to control this one-time process. Procedures covered such items as the development of the system and topical descriptions, creating the data bases used for validating information, and control of the electronic library that would result from this.

It was determined that the establishment of the DBD library system, the DBD development and the UFSAR validation would be concurrent efforts. Utility and former utility employees were recruited to staff teams that would conduct integrated reviews of the design and licensing basis. The culmination of these reviews would be the validation of the UFSAR.

The typical team was comprised of a team leader, a licensing engineer (to write UFSAR change requests) a DBD engineer (available on a consulting basis), a system engineer, an operations engineer (typically an ex-licensed operator that was shared between teams), an analysis engineer, and several discipline engineers (mechanical electrical/I&C) as required.

Each team reviewed a specific system or topic. There was a core of six teams but more were created as circumstances required. These teams were active for over three years and reviewed around 100 systems and topics among all the teams (the review was conducted for more than one nuclear power plant). The teams were able to take advantage of the DBD library system that became operational and evolved during the course of the review.

The process established for each team review was as follows:

Collect data – this included a review of calculations, docketed (formal) correspondence, items in the corrective action system and relevant generic correspondence from the USNRC

Review and determine design basis and design requirements – When available, the DBD was reviewed to determine the design bases requirements imposed on the system by the calculations. When not available, the design bases requirements were created by the team based on the analysis descriptions stated in the UFSAR. The system and component information was then reviewed to determine if they could meet the design bases requirements imposed by the analysis. This information was compared to the STD and included into the STD where applicable. Discrepancies in the STD were classified as DBD open items and entered into applicable tracking systems.

UFSAR Review – The single largest part of the reconstitution effort was the validation of the UFSARs. A database was created and the UFSAR statements were entered as individual records. A total of 42,000 records were entered into the database that required validation. Each record was reviewed to determine the accuracy of the UFSAR statement. Statements that were considered inaccurate, incomplete, or unclear were revised used the existing UFSAR change process. The licensing engineer was responsible for creation of the UFSAR change requests, but all team members reviewed the change request package for concurrence. The database was used as a work management tool that tracked the status of each review team. When the UFSAR validation was complete, the database continued as a living document. Every time a subsequent, post-validation change was made to the UFSAR, the data base was updated to reflect the revised information. The final product before the team disbanded was the UFSAR change request package. After the package was approved, the team, with a different composition, was reformed and the process was repeated for a different subject.

STD development – The STD development project started prior to the validation effort and continued after the validation effort was complete. In the cases where the STDs were developed prior to the formation of a review team, the team found the STD to be invaluable to their review effort. Initially the system and topical descriptions were considered as a separate project but it was later determined that the overall effort would be more efficient if the STD were absorbed into the validation effort and system and topical description authors were members of the validation teams.

Concurrent with the STD development and UFSAR review was the creation of the design basis document library system. During the early stages of the library creation, technicians collected the appropriate documents from the nuclear records vault and scanned them into electronic documents. These documents were copied onto CDs that were made available to team reviewers. Over 100 CDs comprised a library set. Revisions to any documents listed on a CD required a change to the entire CD. Eventually the CD sets migrated to an electronic server and the CDs were discarded. The server has been updated and its capacity expanded several times since the CD information was extracted. However, the same concept is in effect today.

APPENDIX IV. PROCESS CONTROL SOFTWARE CASE STUDY

IV.1. General description and objective

TIPOM is a process oriented software application for management of equipment and related work-flow of documentation changes: This process follows the change from conception (requirement) up to implementation and evaluation. While performing each activity, it is necessary to create electronic records. These records can document technical and economic data. The TIPOM application enables the user to generate required documents from the create data for the purposes of storage and retrieval. This software allows data to be entered only once. The data then can be accessed in real time and used for filtering and creation of user-defined outputs such as printouts. The output data (tables, results of queries, etc.) may be exported to other MS Office applications. The software can also be connected to other (both technical and economic) applications through its built-in interfaces.

The application data is stored in the ORACLE database environment. The restrictions in accessing the data ensure that it is not possible for several users to edit the same data at the same time (record-locking). Record changes are monitored for the time of the change and the user who made it. The administration possibilities for user group privileges settings are almost unlimited – this provides high level of security for access to sensitive data and documents.

A broad selection of functions can be implemented in the software application. The range from those which allow for:

- basic time planning
- calculating project costs
- technical-economic evaluation
- monitoring of the linkages to business assurance
- realization, monitoring of defects and backlogs
- reclamations and temporary changes, up to final evaluation.

There are other tools are available for creating templates of the electronically generated documents. These templates allow for management of generated and imported documents, and for their creation and evaluation of remarks resulting from ‘electronic’ approval. One of the basic functions of TIPOM application is that it supports identification of the impact – the inclinations of the equipment configuration caused by planned technical change.

As previously stated, configuration management is defined as the process of identifying and documenting the characteristics of a facility’s structures, systems and components (including computer systems and software), and of ensuring that consistency is maintained between the design requirements, physical configuration and facility configuration documentation. In case of the nuclear power plants of ČEZ, a.s. this requirement is implemented by keeping consistency among the following areas:

- design basis
- real (physical) condition of the equipment
- equipment documentation
- processes for operation and maintenance (including documentation)
- legislation (both national and international)
- certification and required size of the plant staff.

One of the necessary conditions for fulfilling these requirements is to watch how the change (of parameters, data, requirements, etc.) in one area may impact the other areas. At ČEZ, a. s. the identification of the impacts when the change is initiated is carried out via different processes and by different departments – according to the area the change is identified at. An example of this relationship can be shown in Figure 25.

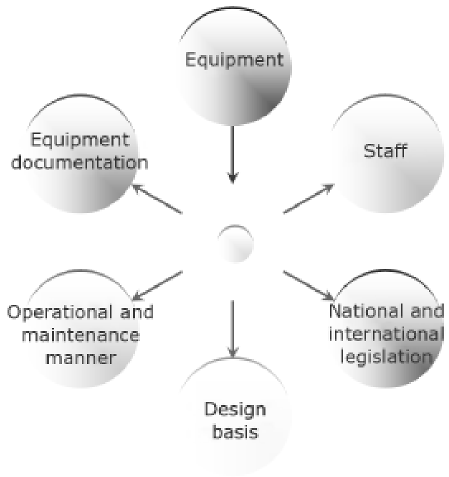


FIG. 25. Management of changes of the equipment configuration – system settings

In the case of a change to equipment documentation or a technical change to equipment (modification, creation, or removal) the TIPOM CEC management module (change of the equipment configuration management) is used to monitor impacts. Also, the possible impacts on related areas are monitored.

For identification of impacts of the suggested change of current configuration it is first necessary to define:

- ‘what’ is to be monitored – i.e. define the selected groups of possible impacts for particular areas to be monitored
- ‘who’ guarantees the evaluation of the selected groups of impacts.

The identification of impacts are set by directive documentation of ČEZ, a. s. By using a matrix, 50 potential groups of impacts are defined. For each of these groups of impacts a department is defined which guarantees the review. There are 54 such units-guarantees.

The TIPOM application allows the administrator to define, arbitrarily extend or modify both groups of impacts and departments that guarantee the review – refer to Figure 25 where the left panel contains definitions of the groups of areas and the right panel shows the units-guarantees.

If required, it is possible to set and change the subsequent attributes administratively:

- the guarantees – the employees responsible for conducting the evaluation in the groups of impacts they guarantee
- delegation of the request on evaluation onto another person (the delegate)
- the e-mail sending modes (the allocation of a requirement, its delegation, the request for approval) according to the guarantee’s requirements

- the mandatory guarantees – the evaluation that cannot be omitted – they are always sent the e-mail
- the lists of values which the impact identification is restricted to (i.e. selection from several options, selection from a list of documents, etc.)
- defining the necessary conditions – without their fulfillment the realization is
- not possible
- defining the types of documents which are to be evaluated – for which the impacts of the suggested change should be identified.

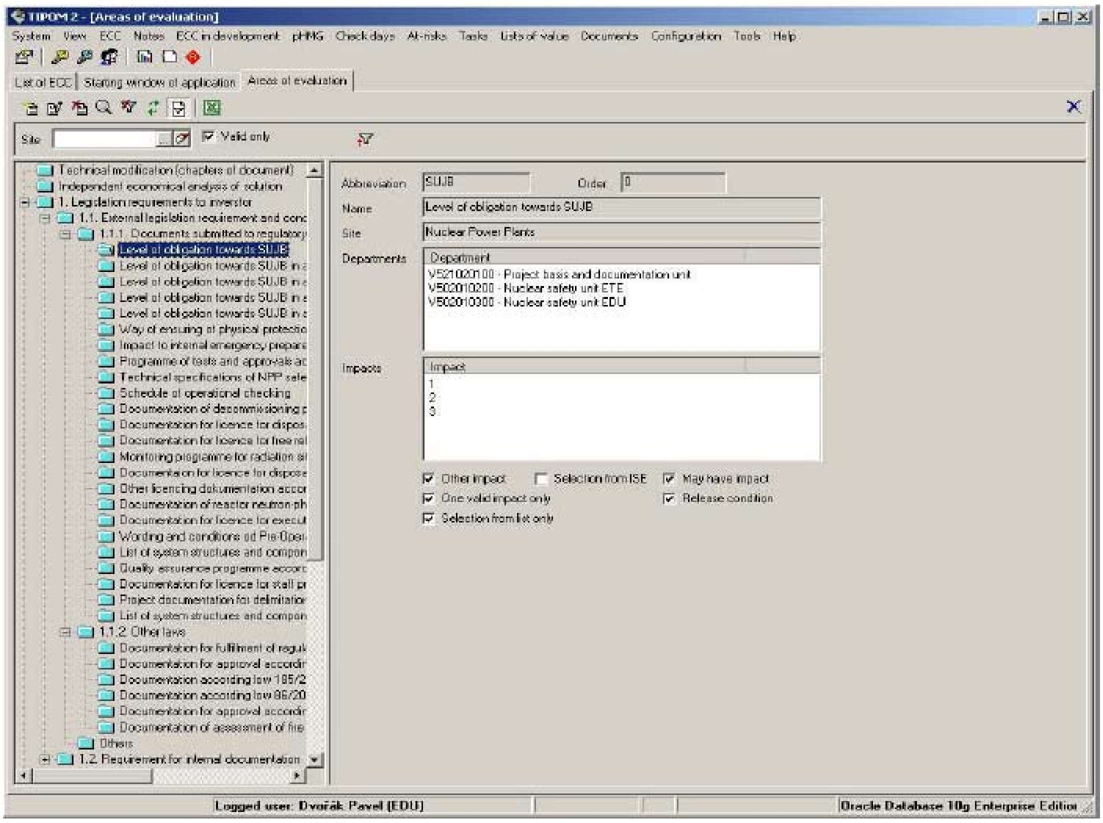


FIG. 26. TIPOM areas of evaluation

IV.2. Management of changes of the equipment configuration – Distributing the review requirement

After a document is created, on the basis of which the review (impact identification) is being conducted, the TIPOM application allows the user to send the requirements to particular guarantees, refer to Figure 27. The departments may be selected via a panel with departments predefined, that cannot be omitted in this reviewing process. In this panel it is also possible to individually enter the time of ending (deadline) of the review, the additional comment and the mode for reminder sending.

The system also allows for sending e-mails to departments that are not administratively defined as guarantees, which – together with the possibilities of administration settings – offers almost unlimited possibilities of use.

Each corresponding reviewer is sent an e-mail message with an active hyperlink that will (after logging into the system) automatically guide him to the review panel.

When entering the impact the reviewer identifies the activity that must be carried out. When it is identified that a related document needs change, the reviewer may add a comment and suggest a way of assurance (e.g. by the supplier with the supplier's name) as shown in Figure 28.

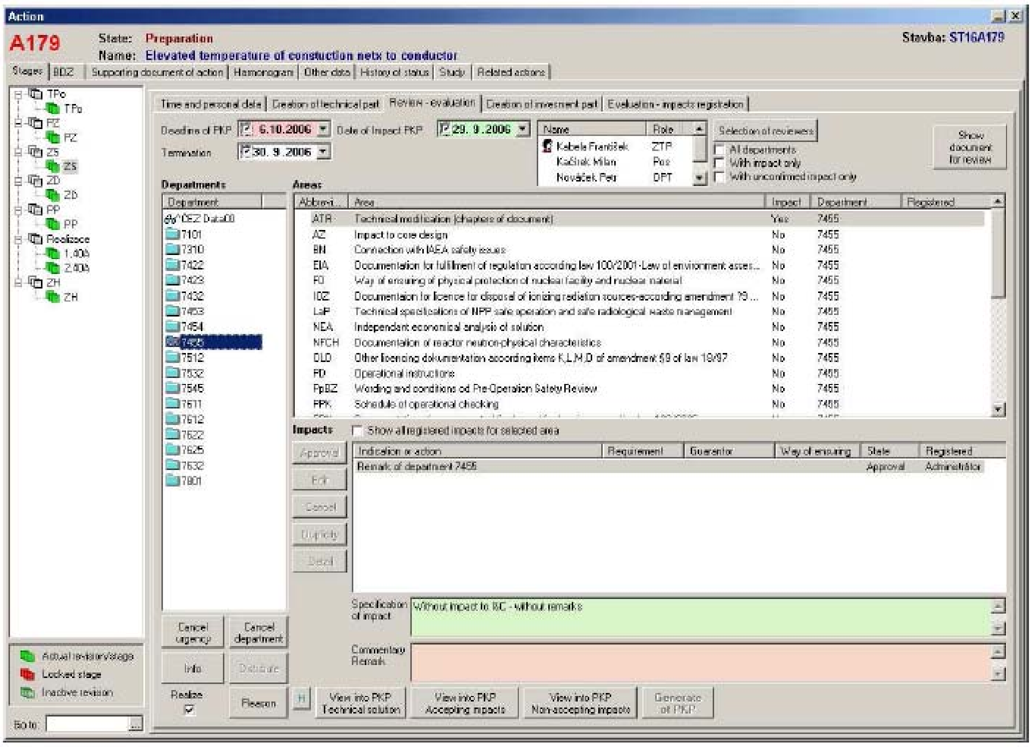


FIG. 27. TIPOM selection of reviewers

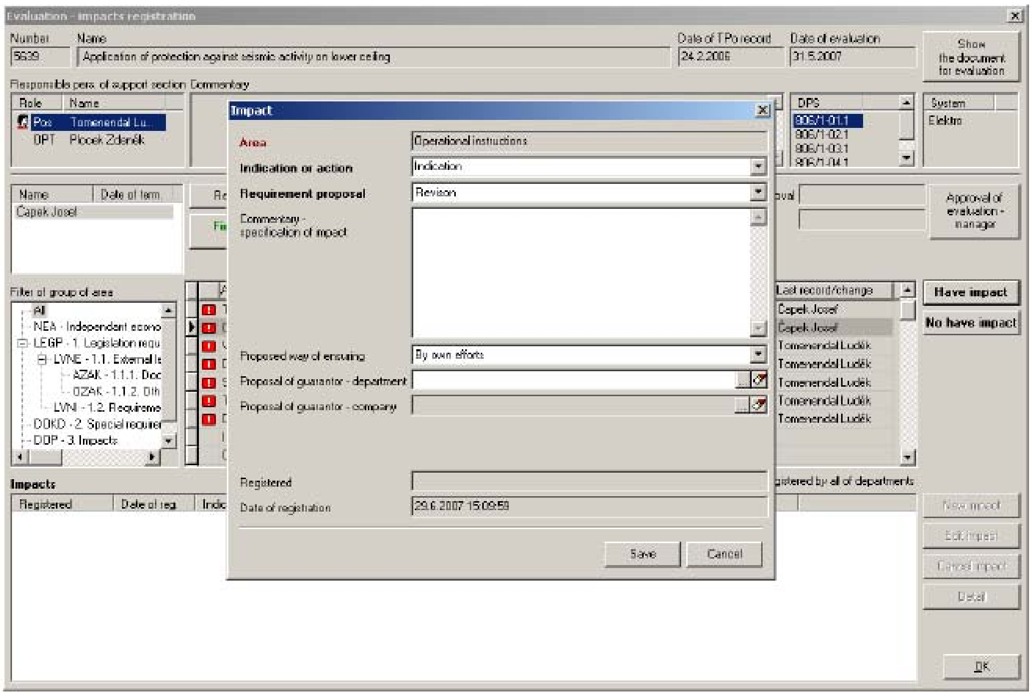


FIG. 28. TIPOM evaluation of impacts

Every record contains the date of entry and the name of the reviewer and every reviewer disposes of his own data area (the data are protected against being changed or modified by employees of other departments). Moreover the application ensures filling of the mandatory areas and automatic sending of reminders in case of deadline expiration. It also allows for delegation of the review to another employee of the same subdivision and for two-stage approval.

IV.3. Management of changes of the equipment configuration – Storing and managing of documentation which described the configuration changes

Apart from standard document storage, the system allows the user to keep track and manage the employee's disposition of particular document and allows for approval. The documents are folders in which files are stored. For each document it is possible to send requirements to employees and perform reviews, to gather the status of particular document and also to implement document approval.

It is possible to set up document approval manually – the user can choose a combination of sequential approvals by the employees. The system uses reminders and e-mail notices to employees, when given deadlines have already passed. It is possible to keep track of documents in paper form as well. In the application the user can use access privileges according to the document type. The files can be stored in an ORACLE database as indexed for ability to use full-text search or compressed to minimize the file size.

The Software allows the user to filter out the remarks that have not been clarified, and view the data selection of all the guarantees or separately. Some information is presented in the form of icons and their colour change, e.g. the ending of the guarantee's review, the entry of an impact for an area, etc.

The final output is a generated protocol in the MS Word format that contains the accepted and rejected remarks.

IV.4. Management of changes of the equipment configuration – The overviews of impact evaluations and their solutions

The system allows the user – in any chronologically subsequent phase of the preparation and realization of the project – to evaluate the identified impacts. Moreover, it is possible to add new impacts that have been identified later during the following phases but not possible to delete the impacts that were originally added during the reviewing of the document on the basis of which the first reviewing is being performed.

As shown in Figure 29, the application makes it possible to search and create reports in compliance with given filtering criteria. This may be done using a panel where the user can limit the selection according to a set of areas, time or given guarantees. The resulting printout can be printed or stored electronically in the MS Word format, including all the information on the impact solution.

IV.5. HW and SW requirements

The TIPOM system is designed for Microsoft©Windows©operating systems; it was developed in the Delphi environment. An SQL database is used for data storage (ORACLE©, SQL Server©, MySQL©, InterBase©, etc.).

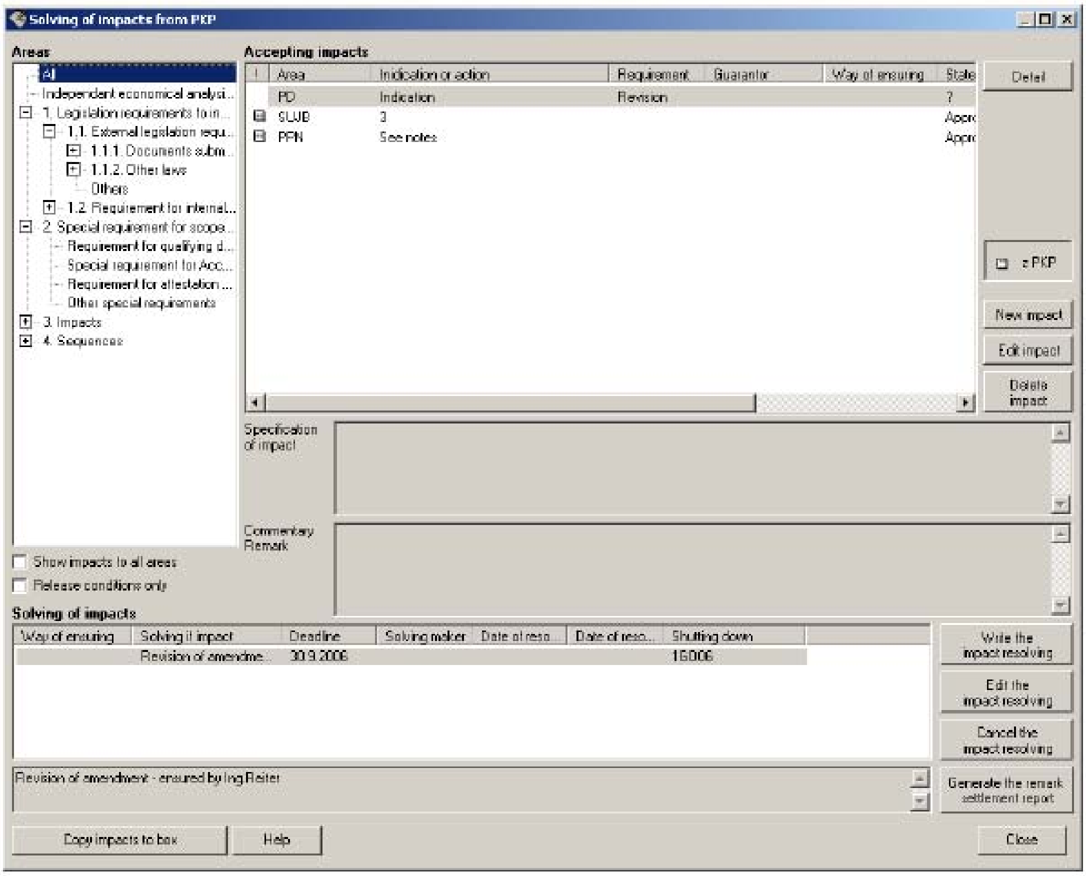


FIG. 29. TIPOM search and create reports

The minimum hardware configuration required to run the programme is an Intel©Pentium©500 MHz processor, 256 MB RAM, 10 MB free hard-drive space, and avideo card with at least 1024x768 resolution.

Reference

The information system TIPOM is developed and created by the specialists of the Czech company ENVINET a.s., www.envinet.cz.

APPENDIX V. IT SOLUTION EXAMPLES FOR ANALYSIS, PURCHASE AND INSTALLATION

V.1. Example of applications using common nuclear power plant database

The process, data and documents controlled by the enterprise CM solution serves as a repository for, and in the case of a PLM solution, the means to effectively maintain and control plant life data which are used to support safety, operational and economic decisions in nuclear power plant operation. Definitions of technology solution functions must be well-understood. For example, nuclear power plant Equipment CM and plant life cycle management (PLM) look very similar, and utilize much of the same data and management.

These nuclear power plant technology solution functions are defined as:

Configuration management – The establishment of equilibrium between plant design, plant equipment content and those documents required to prove this.

Asset management – The establishment of plant equipment material condition and performance history based upon plant design, content and supporting documents in order to establish economics and gain the longest useful life from the asset.

Aging and obsolescence – Identifying and utilizing data to support plant equipment repair, replace and run-to-failure decisions.

Asset retirement – Identify and determine the capitalization limits, retirement dates and accounting impact of plant equipment.

Figure 30 shows the examples of general PLM functions that a comprehensive nuclear power plant IT solution can support. The typical modules for a nuclear power plant IT solution are shown mapped to the four basic plant life management activities associated with nuclear power plants.

V.2. Information system design concepts

Three information system design concepts are discussed below: ‘HUB’, PLM and ERP.

Concept 1: Data-centred ‘HUB’ architecture & relational database design

Data-Centric system designs represented the traditional design methodology for most types of enterprise business software until recently. They are sometimes referred to as ‘repository’ systems, because their major capability is to accept, organize and store data for later retrieval. When functionality and process are added through programming, the software is generally monolithic and rigid, and difficult to change without extensive knowledge of programming and fluency in the particular programme language chosen for the technology

Figure 31 describes the core architecture for relational, data-centric systems should generally follow a ‘Hub’ or ‘Cradle’ concept utilized in many leading commercial MRO/ERP solutions, with some additional features to improve performance and scaleability. The ability to express primary relational data relationships in a form that is the most useful to the integrated solution has been often elusive in commercial applications, mainly because they have usually evolved too far in development by the time the concept is implemented.

CM Business Process	Configuration management	Asset management	Aging & Obsolescence	Asset Retirement
MEL	●	●	●	●
Document and Records Control	●	●		
Engineering Design Change	●			●
Maintenance/Work management	●	●	●	●
Materials Catalogue	●	●	●	●
Materials Inventory	●	●	●	●
Purchasing	●	●		●
Timekeeping		●		
Personnel Qualification	●		●	
Project/Financials		●		●

FIG. 30. Applicability of CM modules and functions to plant life management

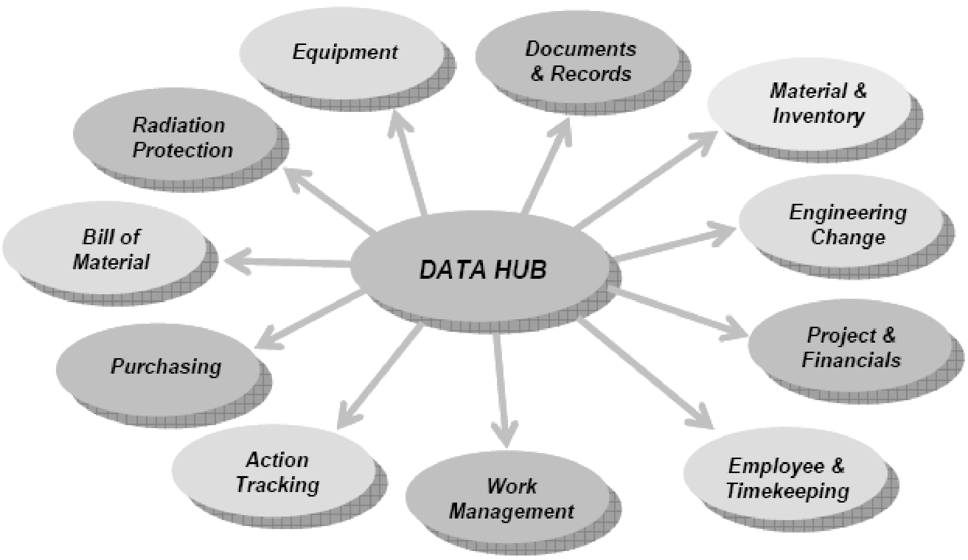


FIG. 31. 'HUB' architecture

The MEL is normally the center of a traditional repository-based system (Figure 32). An advantage of the 'HUB' concept depicted in Figure 31 is the decoupling of the MEL as the de-facto center of the database. While the MEL is certainly critical to success in a CM technology solution, configuration and asset management revolve around multiple pure-data centers of gravity, including equipment, materials catalog, documents, and financial accounts (Figure 31).

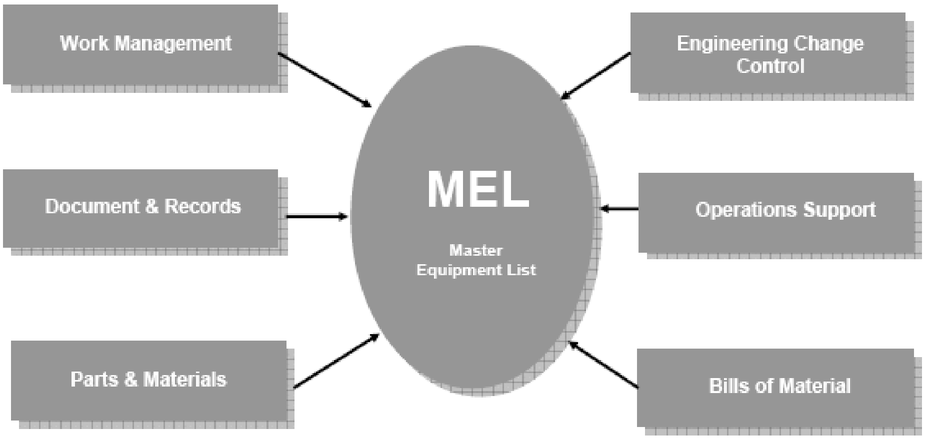


FIG. 32. Master equipment list focus (traditional)

The 'HUB' architecture of Figure 31 has the advantage of reducing or eliminating the need to anticipate all possible data relationships at the point of initial database design. Unlike legacy relational architectures, the data 'hub' does not need to contain data, only relationships, and points out the advantage of messaging technologies such as XML, which can manage 1st to n-normal data key relationships without compromising data integrity, and without data loss. The ability to 'surf' the relationships is a direct benefit of XML-based architecture, similar to that used in complex HTML browsing ('web' searches).

This example would be 'tuned' and enhanced to match specific client data requirements. There may also be sub-codes used for performance or to remove isolated ambiguities. This concept was implemented at nuclear power plant Krsko in Slovenia, but only as a navigation tool. (It was too late in the KPMIS development process to implement the concept as a part of the basic architecture.)

Virtually every data entity of plant MRO, ERP and CM data can be related to one of the links, through either simple key alone or compound-key joins. This concept is particularly useful to design applications in an XML environment, because XML, unlike relational database designs, does not rely on the physical table relationships to describe cardinality and normal forms of data relationships.

Other select modules do not represent a first-order normal event in the database. For example, even though radiation protection does have discrete functionality, the data requirements for RP functions consist of the combination of employee ID and RWP number. These are represented completely by other n-codes (through the work order/task number). No radiation protection key value is required to distinguish the data event further.

This also ensures fixed, predictable 'paths' for principal data cardinality relationships. Most anticipated configuration management and asset management data relationships and events are pre-loaded and represented in the design, for the majority of the nuclear MRO, CM, asset and resource management business processes to be supported by the CM Solution.

Figure 33 shows examples of database design that demonstrate the design's ability to create the correct relationships for major nuclear power plant activities and events.

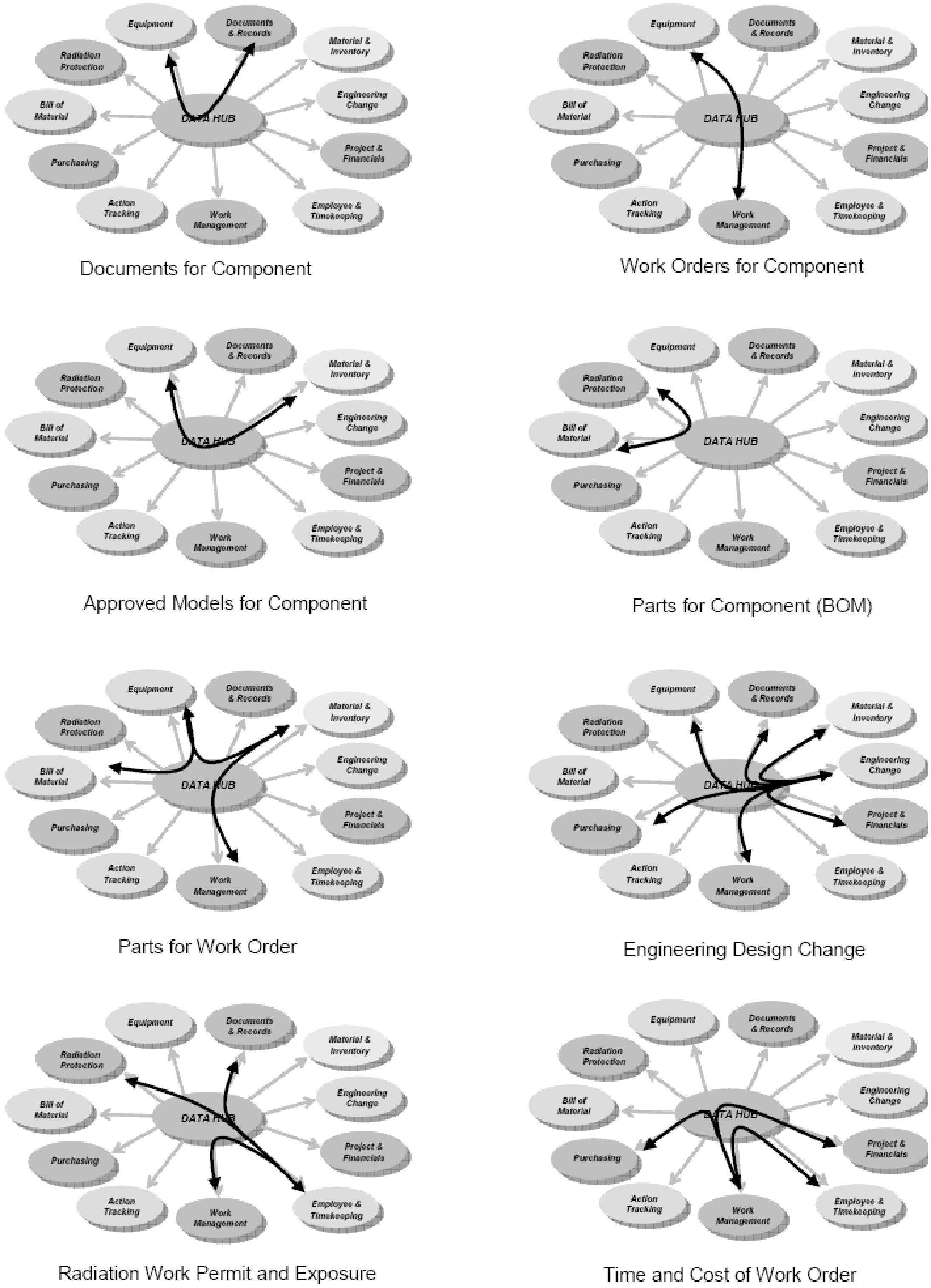


FIG. 33. Examples of nuclear power plant data & query relationships

The proper implementation of key data relationships are the basis for solving most basic business process challenges, while identifying redundant data and work through systems integration. For example, when properly integrated, and when the correct process and granularity is established, work orders and tasks may be utilized for direct posting of cost, labor, project and schedule information to the financial system.

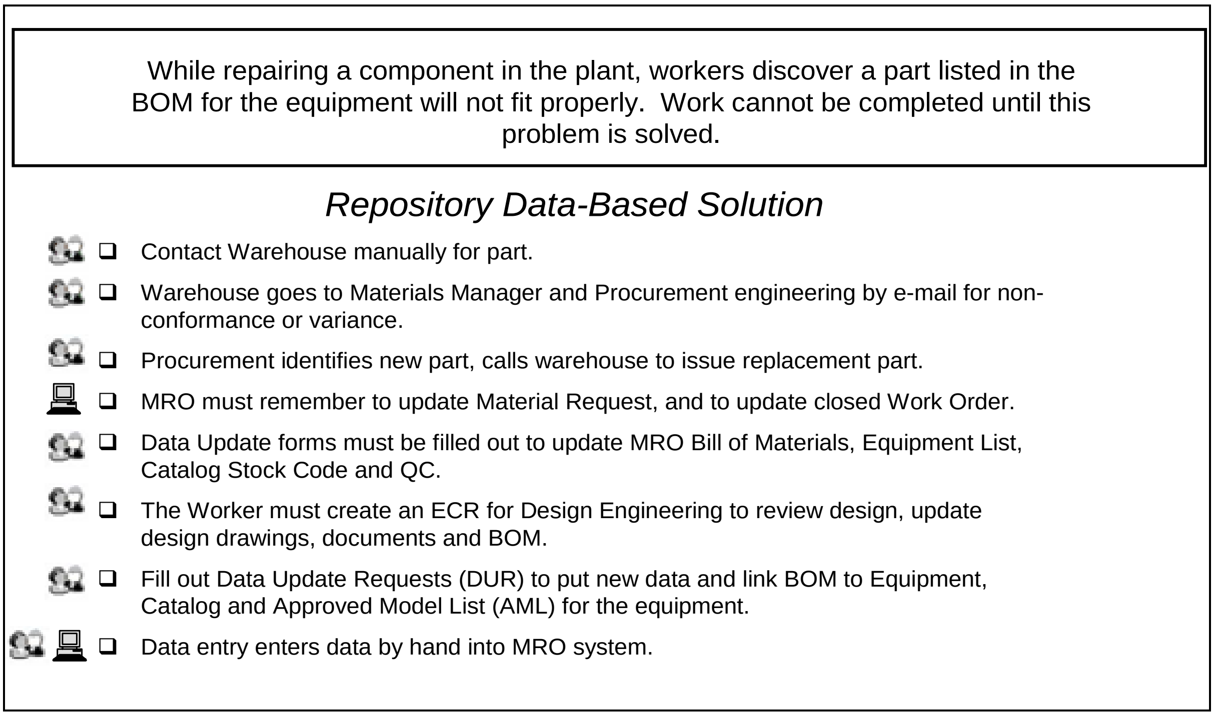


FIG. 34. Repository database example

Figure 34 utilizes a typical nuclear power plant operational problem, to be solved in the context of each of the two design concepts presented here. In this case, the operational problem is resolved utilizing more traditional 'repository'-based IT solution. In a later example, the PLM-based solution is utilized (Figure 37).

Concept 2: Plant life cycle architecture

The PLM concept is readily designed to accommodate the 3-tier organization of data and document sources (Figure 35). Configuration management concepts, nuclear power plant business rules and design input may be initially made using the 'data-Based' method as a tool, then introduced to the PLM environment. PLM centers on change management principals, and dramatically improves configuration management effectiveness through CM awareness and integrity by ensuring that all affected personnel and events are notified of nuclear power plant changes or discrepancies.

- PLM forms the design documentation – it is updated in real time, as you go, and can be printed for hardcopy later. The final 'Update Documents' step is eliminated.
- Repository solutions rely heavily on printed procedures, corporate (anecdotal) knowledge and 'word-of-mouth'. When rules change (if captured), computer programmes must be re-written and user interfaces re-created.
- Frequently, rule or procedure changes are not captured in documents used to update Repository-based systems.
- PLM-based systems have business rules, procedures, processes and corporate knowledge integrated into the system. These rules are introduced through the IDE Modeler and contain the procedures for conducting nuclear power plant business. The PLM client is Outlook-based, and does not rely upon 'fixed-real-estate' screen forms.
- PLM eliminates data update and discrepancy reporting, automates data and process QA.

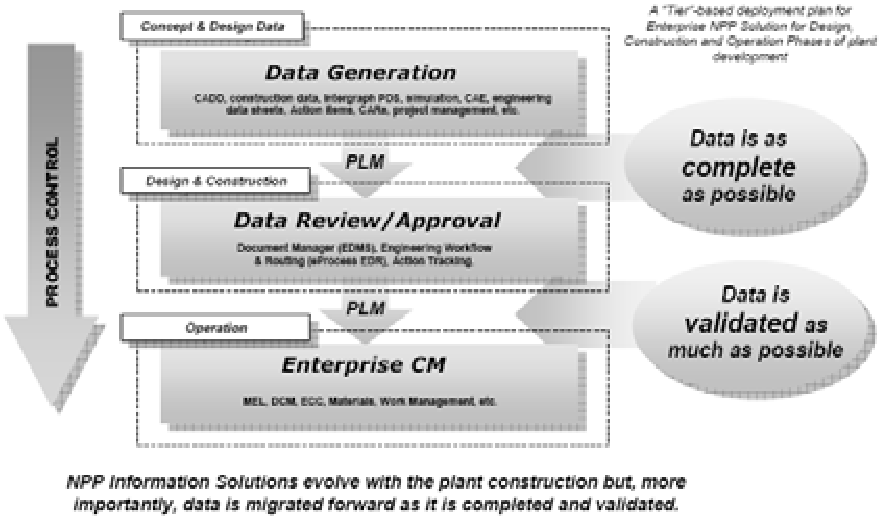


FIG. 35. Plant life cycle management

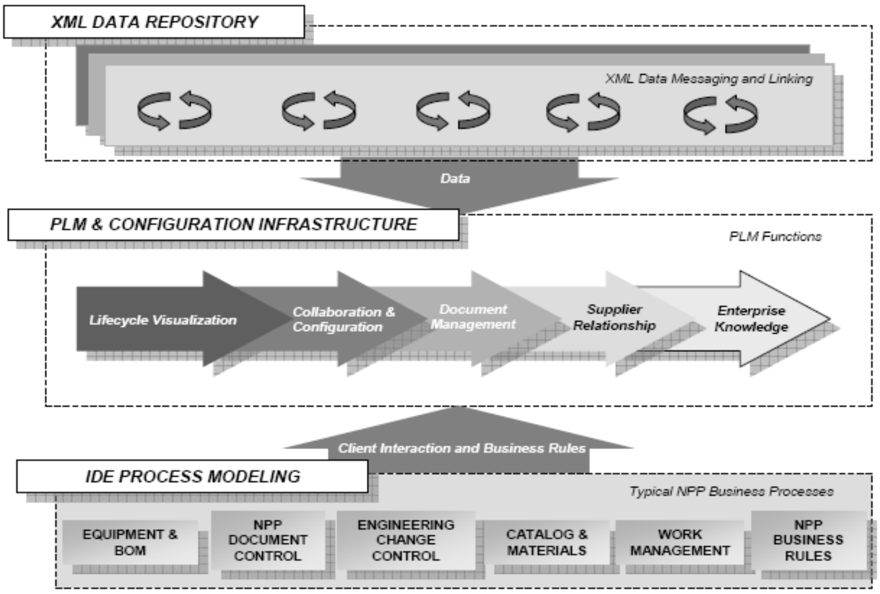


FIG. 36. PLM architecture

While repairing a component in the plant, workers discover a part listed in the BOM for the equipment will not fit properly. Work cannot be completed until this problem is solved.

PLM Solution

- ❑ The part misfit is entered in the MRO Client.
- ❑ Immediately the PLM process sends Lifecycle and RM messages to the warehouse, MRO Material Request, procurement engineering and design engineering for the part discrepancy.
- ❑ When approved, PLM automatically adds the Part Number to the Bill of Material. Procurement sees an RM notice from PLM for the BOM for equipment number, Purchase Order, Make/Model and Part Number.
- ❑ Design engineering and procurement can either issue a Non-Conformance or Variance. Procurement Engineering generates ROP to Purchasing to buy, or warehouse issues the new part on the MR and the work is completed.
- ❑ No need to note the part discrepancy on the Closed Work Order, PLM already knows.
- ❑ PLM record is updated and included in Documents. PLM documents the transaction and the data in the system. CAE data feeds back to CADD system.

FIG. 37. PLM example

Nuclear power plant solutions utilizing PLM have much more impact on the change management mechanism, while enjoying the ability to separate functionality and business from basic programming technology. This facilitates software upgrades and maintenance without having to re-create custom applications or business rules.

The PLM architecture (Figure 36) places change management and notification in an enterprise software environment, and utilizes data as a service, not as the hub of the system. This effectively de-couples data and application, simplifying programming and upgrades.

Figure 37 is the companion to Figure 34, 'Repository database Example', showing how PLM solves the previous sample problem with significantly less human interaction

Concept 3: Enterprise resource management

ERP software is a companion technology solution to the Enterprise Configuration management (ECM) solution, and supports the asset management and plant lifecycle cost and retirement objectives of asset management and plant life extension. ERP systems receive raw work order, project account, parts and labor entry data from the CM system (sometimes referred as MRO data). The ERP can then assign unit and total cost to the work order or project and determine TCO to a given equipment item. In addition, these data can be converted into ledger accounts and mapped to the nuclear power plant or owner utility chart-fields for cost accounting, billing and/or accounts payable as needed.

Successful ERP implementation depends upon:

- Ability to convert Work and Procurement invoices into Accounts Payable events on the MRO and EPC sides of the CM system
- Ability to represent Procurement P.O.'s and Parts as ERP entities
- Ability to manage Inventory events, such as warehouse receiving, QC, and MRO material requests (issue and return)
- Facilitate metrics such as spend analysis and safety stock
- Granularity of the Work Breakdown Structure, or WBS
- Matching work order and project Numbers to ERP Charge Accounts (or work orders) for work and Design Changes
- Integrate with plant room, system and equipment coding and numbering systems whenever possible
- Understanding how the ERP converts Work into Money
- Understanding what information the ERP needs from MRO and CM systems to describe, establish and track the nuclear power plant as Assets.

The work order (MRO) cycle is shown below in Figure 38, mapped to the ERP data collection and processing. Asset condition and costs are passed to both engineering and financial activities.

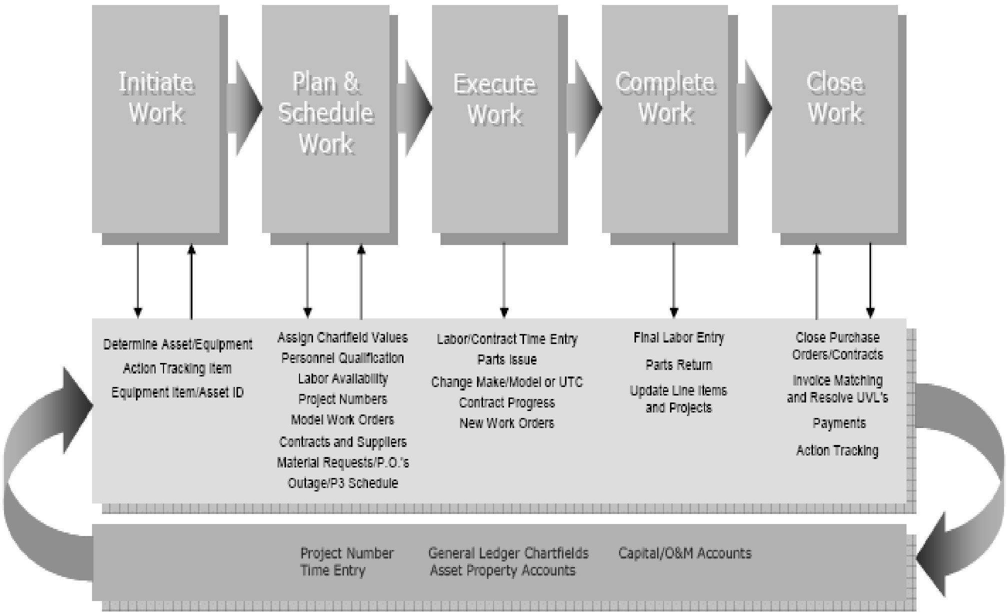


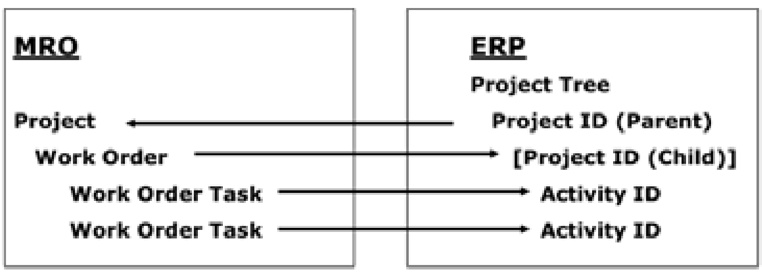
FIG. 38. Traditional MRO work order cycle mapped to ERP

The work order to ERP flow shown in Figure 38 also illustrates the three media used to record, track and manage nuclear power plant work costs:

- Labor Entry (LE) – personnel timekeeping, used for both employees and seconded hourly contractors
- Purchase Orders (PO) – Used to request services, labor, parts and materials from outside the nuclear power plant facilities or inventory stocks
- material requests (MR) – Used by work orders to request stock items from inventory. If stock cannot satisfy the MR, a requisition is automatically issued.

The part is either ordered from catalogue, or identified by procurement engineering and specified for order on a P.O.

Nuclear power plant work orders may be ‘mapped: to the financial system through the use of financial ‘work orders’ or ‘projects’ in the ERP system. Labour, costs and schedule may then be coupled with the nuclear power plant work orders.



1. Accounting added at MRO work order task level
2. All resources used in the performance of work are charged to a work order task in MRO system
3. All work order task related commitments and actual results are captured in the MRO and sent for update to ERP projects

V.3. Configuration management IT application checklists (related to text section 5.8)

The following checklists may be utilized to select, install and deploy a CM IT Solution based upon nuclear power plant functional requirements and configuration management needs.

Functional checklist for MEL module

Traceability data is controlled to be updated through only one of the following:

- Design Evaluation Request
- Design Change Package
- Document Change Request (DCR)
- Data Update Request (DUR)

Decisions/Options

- Equipment Revision Control
- Component/Associate Levels
- Validation Tables (Equipment Types, Facilities, Building ID, etc.)
- Cross-reference of legacy numbering data with nuclear power plant native data.
- Controlled Document Cross-References are entered by MEL update.
- Inclusion of Commodities, such as Fuses
- Inclusion of bulk structures, such as Pipe Hangers/Snubbers

These Equipment/Component ID and Determinants are utilized for controlling and planning of nuclear power plant work orders

- Materials and Parts to be used
- Bill of Materials to be utilized (for the Make/Model Installed)
- Outage or Plant Isolation/Lineup Change to be followed
- Other Equipment affected (Air Supplies/Power Supplies)
- Tools and M&TE to be used
- Personnel to be obtained
- Personnel Certifications to be verified
- Codes and Standards to be followed
- Documents to be utilized
- Records to be produced

Equipment List Content

- Design and Operating Factors data (Revision n+1)
- Parts (and Qualification) or substitute
- Determinants (Attributes)
- Permits
- Associates/Air-Power Supply
- EQ and Programmematic
- Installation and UTC history
- Operating Factors/Parameters (Alarm, Limits and Setpoints)
- Operational Readings
- Bill of Material

- Repetitive Maintenance data and intervals
- Model work orders

Equipment Metadata and Characteristics

- Is a Position
- Has Equipment/Tag Number from a DBD (Drawing, SAR, etc.)
- Can usually be identified on a One-Line Drawing, P&ID or Flow Diagram
- Has a DB
- Has Design Requirements

Component ('Parent') has the following qualities:

- Is a Physical Device
- Fulfills a DB function (Component, and/or as part of a system)
- Has Manufacturer Specifications
- Has a Stock Code
- Has a Purchase Order
- Has a Make/Model, Associated with it, from a Table of Approved Models
- Usually has a Serial Number/UTC
- Has a Bill of Material
- May have Qualification.

Component/Sub-Component ('Child') has the following qualities:

- Is a Physical Device (usually attached to or integrated with 'Parent')
- Fulfills a DB function, as part of the Component or System
- Has Manufacturer Specifications
- Has a Stock Code
- May have a Purchase Order, or be integrated with Component (OEM) P.O.
- May have a Make/Model, Associated with it, from a Table of Approved Models
- May have a Serial Number/UTC
- Has a Bill of Material
- May have Qualification.

Functional Checklist for Document Control/Records management (DC/RM) module

General Process

Document data are updated through one of the following:

- Design Evaluation Request
- Design Change package
- Document Change Request (DCR)
- Record Interim Drawings and Design Change Notifications (Open modifications)
- Receipt of New, Revised or Superseded document
- Cancellation of Controlled Document
- Maintenance of Document and Records Type Lists
- Controlled Distribution Event (Distribution, Acknowledgement)

- Distribution of Document/Procedure Change Notices (minor changes)
- Receipt of Quality Records Turnover and Supplement

Decisions/Options

- Types of Controlled Distribution
- Validity period of Working Copy Documents
- Establish/Assign Document and Record owners in DTL/RTL
- Cross-reference of legacy documents and current data with nuclear power plant native data.

Document and Records Content

- Identity – (Type), (Sub-Type), Document Number, Sheet, Revision
- Distribution List
- Media and Instance Types
- Cross Reference to Equipment, work order, Action Item, ECC Modification
- Turnover to Quality Records
- Records Retrieval Guidelines
- Document/Records Type List (DTL/RTL)
- Procedure Index

Functional Checklist for ECC module

General Process

- Open design modification by number
- Review and finalize Affected Equipment, Documents, BOM's
- Review and set Milestones and Attributes for Modification in CM
- Indicate 'Incorporated Y/N' flags in CM for document changes as necessary
- Initiate parts procurement from Catalog entries or new parts (Catalog only for CM)
- Ensure Closeout of work orders, Commissioning and Modification package

Decisions/Options

- Types of Milestones and Attributes for Design Change Types
- Toggle Equipment Revision ON or OFF (ON recommended)

Inputs

- Equipment Items (Revision n)
- System
- Documents and Drawings (Revision n)
- Components (Make/Model/Serial Number)
- Design and Operating Factors data (Revision n)
- Bill of Material (for Make/Model) (Revision n)
- Bill of Material (for Equipment Number) (Revision n)
- Parts (and Qualification)
- Requirements
- QA plan (large MOD)

- Regulatory
- Project
- Budget
- Asset data

Outputs (potential changes)

- Equipment Items (Revision n+1)
- System
- Documents and Drawings (Interim Revisions A,B,C …)
- Components (Make/Model/Serial Number)
- Bill of Material (for Make/Model) (Revision n+1)
- Bill of Material (for Equipment Number) (Revision n+1)
- Design and Operating Factors data (Revision n+1)
- Parts (and Qualification) or substitute
- Purchase Orders (Line Items)
- External Contracts (Voucher points)
- Work Orders – Installation
- Work Orders – Maintenance Preventive/Emergent
- Work Order Material Requests
- Plant Tag and Clearances
- Labor Tracking/Timesheets
- Cost and Line Item
- QC/QA packages (Construction ‘Turnover’)
- Documents and Drawings (Revision n+1)
- Account Payables and project Closeout
- Register Asset Changes.

Design Change Process

The design change is controlled by milestones and attributes for the design change type and size (cost). The milestones should determine particular actions to be performed and deliverables to be created prior to a given date (or prior to the next gate, stage or phase). Attributes are static, usually non-time-related items which must be satisfied prior to moving on to the next gate, phase or stage.

ECC Content

- Request
- Feasibility
- Review and Approve
- Classify Modification Type
- Adjust default attributes/milestones
- Assign Lead Discipline, Engineer
- Regulatory and License Review
- Standards Review
- Third-Party Design

- Conceptual Design
- Technical Design
- Long-Lead Parts and Components
- Final Design Approved
- Engineering Procedure Create, Update, Review
- External Procedure Create, Update, Review
- Installation work orders
- Clearances and Tags (Operations)
- Installation work order Cycle
- Interim Drawings and Documents
- Design Change Notices
- Test and Commission
- Available for Service
- As-Built/Final Documents
- Closeout and Documentation (Design, Drawings, work orders, Procurement
- Evaluations).

Functional Checklist for Work management module

Work orders for Engineering Changes

- Identify/work request
- Consolidate/Plan
- Schedule
- Outage Schedule
- Preventive or Emergent Work
- Clearances and Tags (Operations)
- Execute
- QC and Inspection
- Startup Test
- RTS
- Complete Work
- Close Work Order (Modes, Payables, Failure data, Rework, Follow-on, Parts Return)
- Documents and Records

Functional Checklist for Materials and Procurement module

Procurement for Engineering Changes

Sources: Engineering Change Request, work order, Commercial Grade Dedication Request, Non-Identical Replacement, Qualification Requirement.

- Evaluation and Identification of Part
- Qualification
- Vendor
- Determine Grade: Commodity/Commercial Grade/Qualification/Serialized Item
- Traceability (Serial Number/Lot Number/Special Markings)

— Stock data (Safety Stock, Min/Max, Bin Access, Remote Warehouse)
— Vendor (Reorder, Lead Times, etc.)

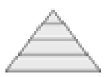
Stock and Inventory

— Receiving
— Quality Control Inspection
— Shipment Document and Records Delivery to Document owner
— Stock, Shelf management and ABC Analysis
— In-Storage Maintenance
— Stock Rotation
— Serialized Item management and Traceability
— Stock Issue/Return
— work order material request Number

V.4. Design process checklist for configuration management IT solutions (related to text section 6.2)

The following process checklists are suggested for development of any large-scale enterprise technology solution, such as configuration management. Each item is then listed for items to be completed in this section.

Requirements & Business Process Improvement

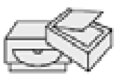


- ❑ Existing NPP procedures are reviewed for processes that support CM Goals and Requirements
- ❑ New procedures, or additions to existing procedures, will likely be required to implement CM processes not currently in place at the NPP
- ❑ Assessments of processes, procedures and existing facilities is made, along with interviews of key NPP staff for process requirements and wishes
- ❑ Industry Standards and world NPP experience serve to verify existing processes and enhance CM functionality

Business Model, Rules for Functional Specification

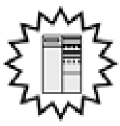
- ❑ The Procedures, Processes and Requirements gained from the *Procedures and Process* phase are analyzed and distilled into the core Business Functionality required for CM.
- ❑ The Functional Specification for the CM Information System is then created from the Business Model and Rules/Requirements
- ❑ The Functional Specification may then be used to design the databases and software to implement CM
- ❑ A database model may be commenced at this point, to be refined later as the design progresses

Data Sources, Acquisition, and Migration



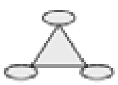
- ❑ **CM data comes from the following sources:**
- ❑ Design Basis Documents (Design Input)
- ❑ Controlled (Design Output) Drawings, Documents and Specifications
- ❑ Legacy Databases and Documents utilized to collect data prior to CM Information System
- ❑ Walkdowns of NPP Equipment and Systems
- ❑ Engineering Design Change Packages
- ❑ Procurement Specifications

Information Technology Infrastructure



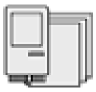
- ❑ Extends to all business functions and activity centers at the NPP for data entry and query functions
- ❑ Utilizes commodity application and systems software that is commonly used, supports large amounts of commercial software, and is familiar to programmers.
- ❑ Utilizes modern, well-tested TCP/IP over Ethernet network protocols.
- ❑ Processor and storage is sized to accommodate the volume of data and processing transactions anticipated, with headroom for system capacity growth.
- ❑ A security system that will protect data integrity and control access as required.

Industry Standards



- ❑ Regulatory Requirements for Configuration Management and Design Basis Solutions
- ❑ IAEA, US Department of Energy, NIRMA, EPRI, WANO and INPO, as well as numerous organizations such as NEI and the CM Benchmarking Group
- ❑ Commercial solution and feature review
- ❑ Graded Approach to CM, including Equipment, Documents and Safety Systems
- ❑ Organization and Interfaces to best support CM
- ❑ Processes to include in CM, and how best to use them

Legacy Systems and data

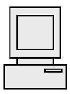


- ❑ Most NPP's have collected significant CM-related data, often without realizing it
- ❑ Legacy CM data resides in many documents and desktop computer database, spreadsheets or document files
- ❑ An existing Maintenance Management, Engineering or Materials application or database likely contains valuable CM data
- ❑ Legacy data is more often than not the most accurate data, since it is used daily and directly relied upon for plant work
- ❑ Legacy systems may exist on IT servers or desktop computers
- ❑ Paper data and records may also contain significant CM data, such as engineering design changes, procedure index, records lists, etc.

Sample Legacy Systems, Hardware and Data Questionnaire

- Does the nuclear power plant have an enterprise IT architecture and strategy?
- If nuclear power plant designs their own system, the only issues may be capacity, upgrades and (possibly) expansion.
- If the selected commercial system does not fit this architecture, than new hardware must be considered. But, nuclear power plant must ask why this system is being purchased – unless a new hardware architecture was planned anyway.
- Attempts at data conversion for CM will reveal much about nuclear power plant data management and mistakes made in the past. If not converted properly, legacy data may be of little use.
- Data formats must be converted for the new system. This is easier if designing in-house.
- Data must 'normalized' against the previous nuclear power plant CM context, or legacy data items may be of little use.
- CM Data previously captured in Word, Excel or other 'flat-file' formats may be surprisingly useful, may be manipulated easily, and is often the easiest to migrate.
- Existing formal database conversion is the next most difficult scenario.
- Legacy hardcopy data are the most difficult to capture, and will require manual research and review as well as conversion to electronic images through optical scanning, etc.

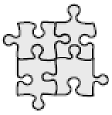
User Interface – Screens and Logic



The Screens and forms used for the CM Information Systems user interface control the process and sequence of data access, including:

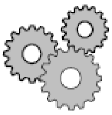
- ❑ User Access to CM Modules, applications and data
- ❑ Addition, Change or Deletion of CM Data
- ❑ Navigation to proper screens for functionality of module
- ❑ Manage Preform and Ad-Hoc queries
- ❑ Format and Validation of user input prior to database commitment

Interfaces and Cross-References (Relational databases)



- ❑ CM Information System modules depend upon integration and cross-reference tables
- ❑ The sample CM relational data model shows the CM modules and relationships of the cross-reference data keys
- ❑ Critical cross-references, such as Equipment-Document, Design Change-Equipment/Document and Parts-Equipment can be complex and require dedicated resources to maintain.
- ❑ The CM system modules also require soft interfaces to other NPP data sources, such as Personnel Qualification, Training and Document Management software.
- ❑ PLM-based systems have this capability built-in.

System Specification, Programming and Testing



- ❑ The CM Functional Specification containing the processing, business rules and data requirements must be translated into software code, databases and user interfaces
- ❑ The programmer/analyst will convert these requirements into the programming language utilized in the current NPP IT architecture
- ❑ A data dictionary will be developed, describing the name, type and size of each CM data attribute, as well instructions for converting relevant CM legacy data
- ❑ The User Interface screens, features and functionality are designed after considering CM design, human factors, data access and security and user requests

APPENDIX VI. VALIDITY OF THE SYSTEM AND TOPICAL DESCRIPTION USED BY THE IT SOLUTION

VI.1. Establishing the system and topical description programme

An effective STD programme should be responsible for the creation, development and maintenance of STD. The programme should contain appropriate documents for control of the STD. A high level procedure should control the update and maintenance of the STD. Items such as update frequency, types of changes, and required format would be in this document. A lower tier or guidance type document would control the writing style and format.

System descriptions **–** These documents address all the aspects of a selected system. The System Description establishes, summarizes, describes, defines, and documents the specific functions, design criteria, design requirements, or other design basis information of a system. Files in the electronic library are linked to the system description. Thus the system description provides a roadmap to information in the design basis document library. The information contained in the system description is all about the system and only about that system. Relationships with other systems and system boundaries are included.

Topical descriptions **–** These documents address the aspects of a selected topic (e.g. flooding, earthquakes, external hazards, high energy line breaks). This comprehensive document that establishes, summarizes, describes, defines, and documents the specific design criteria and design requirements or other design basis information of a topical subject that addresses design criteria that are applicable to the topic. In this case the topic can cross the boundaries of multiple systems. For example, the topical description on flooding would address the protection for all the essential systems that could be impacted by a flood. Similar to the system description, the topical description contains links to the files in the electronic library. The topical description also provides the roadmap to design and licensing basis information related to the selected topic.

The development and revision of STD is included in the STD programme. The programme must be managed by a supervisor or higher level and should be staffed with appropriately qualified and experienced engineers and other personnel knowledgeable in engineering and design basis topics.

The development programme has the following objectives:

- Identify, assimilate, and organize information that is related to the design and licensing basis, engineering documents and supporting information; into encyclopedic-type documents that identify and summarize design basis commitments and requirements, including a directory of supporting engineering documents
- Identify, assimilate, and organize engineering design basis information used by architect engineers, nuclear steam supply system manufacturers, and others that have served as a design control authority, into DBDs
- Provide documented references for design authority and other personnel to use in the configuration management and engineering processes
- Identify applicable codes and standards for equipment described in the STD
- Identify significant licensing bases for plant structures and systems, and include such bases in STD
- Capture institutional design basis and engineering knowledge/information and document such information, as appropriate, in the STD

- Provide a history of the system or topic design including a listing o modifications that have been performed.

In addition to being a roadmap to design and licensing basis documents, system and topical descriptions can be used to support a variety of plant activities. However, without a clear sense of the objectives that the STD are developed to achieve, the STD programme could produce documents of little or no value to the intended users. Thus, it is important that objectives be identified as an initial step in the programme. As STD are developed, they should be evaluated by the degree to which they fulfil the programme objectives. Also, the users (customers) of the STD should be surveyed to determine their needs and preferences. The following attributes should be considered for design bases programmes.

- Provide a documented reference for engineering personnel to use in the design process when considering future plant modifications
- Serve as a basis or provide information on the documents that can be used as the basis for engineering, safety and 10 CFR 50.59 reviews
- Provide a documented reference or the roadmap to the documented references to support operability evaluations and determinations for continued operation
- Provide a documented reference or the roadmap to the documented references for licensing personnel in support of licensing analyses and updates to safety analysis reports
- Provide a documented reference or the roadmap to the documented references to support the review of technical specification changes

Development of the STD should be controlled by a writer's guide. This document would be different from the procedure that is used to control the maintenance update of STD. The writer's guides provide guidance on format, content, and proper use of references and acronyms. This would allow for consistency within any individual STD document and between different STDs. This would allow the readers of the STDs have a familiarity with the style and content of the STD and a high comfort level with the depiction of the information within.

An essential part of the STD development is the review of the draft STDs. Identification of the reviewers that can provide the best value is important. Reviews by the design authority, independent reviewers, and operations would be the minimum. A formal comment resolution process procedurally controlled would be beneficial. Timeliness of reviews is of major importance. Review cycles that result in late and last-minute comments force the system and topical description authors to respond quickly may create an error-prone situation. Comments should be provided as complete sentences or at least meaningful phrases. Responses should be provided the same way. Comment resolution should include discussions with the commenter when necessary to understand the comment or to discuss and resolve differences of opinion. For items that cannot be resolved, an open item may be appropriate.

The STD author is responsible for resolving comments and providing a consolidated set of comment resolutions. All comments should be resolved in a manner acceptable to both the commenter and the author. Training on STD format, construction and intent to the parties that conduct STD review would assist in the review process by eliminating unnecessary comments on scope and format.

Changes to the STDs would be performed by procedurally-controlled change requests and could be categorized under the following classifications:

- Editorial changes – changes that do not change technical content or basic requirements but could be characterized as corrections to obvious typographical errors, including instances where information is determined to have been inadvertently changed (i.e. meaning no intent to change the information) and the correct information is clearly identified as belonging in the document.
- Technical changes – changes that involve actual changes to the design and licensing basis, physical configuration or operation of the plant as described in a STD.
- Generic changes – changes that are not specific to any one system and topical description, but may impact a number of STDs. Generic changes could involve such items as a facility change in compliance in a code or regulation that would affect a number of STDs.

A STD must be designed to serve a number of users. While the primary users are engineers and designers, the STD would have significant value to other facility personnel, including, but not limited to, operating, licensing, maintenance, and training personnel. The target audience of the STD is the user who has a comprehensive understanding of the nuclear facility and has sufficient knowledge, understanding, and experience to apply the information contained in the system and topical description correctly. The STD would not be designed as an introductory text since the user must be knowledgeable and experienced to understand and apply the information in the STD; however, it should provide a history of the subject topic to assist in the understanding of the current system or topical requirements.

VI.2. Relationship to configuration management and design basis

With respect to STD, configuration management is the process of maintaining the physical plant and the controlled documents required to support plant operations consistent with selected design documents. A subset of that is design control. This is the process that is used to ensure that information from design input documents and design process documents for systems, structures and components are correctly translated into the final design. Configuration management and design control support plant operations by preventing undocumented and inadvertent changes. Design bases programmes supplement and support configuration management and design control by providing the infrastructure for the design bases and supporting design information. From this infrastructure, configuration management and design control can evolve and ensure that design bases requirements are met.

The intent of establishing a design bases programme is to organize and collate the design bases, supporting design information and references that together provide a full and complete understanding of a plant's design bases. Experience has shown that there are economic and operational benefits from a design bases programme that includes the collation and assessment of both design bases and its supporting design information. The collation of both design bases and supporting design information into one system or topical STD can serve as a valuable reference for intended users in support of selected facility activities. Also, by providing a standard, well defined, and controlled interpretation of a plant's design bases, STDs can enhance existing design control and configuration management.

Information contained in STDs should be validated, maintained current and controlled to provide a reliable basis. Also, the information should remain readily identifiable and easily retrievable by end users in the design basis library. The validation of the information provides reasonable assurance that the design bases information is consistently reflected in the physical plant and those controlled documents used to support plant operation.

Several methods of validation may be used. The preferred method is integration into the STD development process. The validation may be performed subsequent to development of a STD and incorporated into the STD via change requests. In this case the need to perform the validation should be identified as open items.

Alternative methods of validation include sampling of data for accuracy, field confirmation of essential attributes, programmatic review or any other method that establishes that the information within the STD is consistent with the plant configuration.

Development of a comprehensive set of STDs may require several years to complete. This represents a significant financial commitment requiring facility management support and monitoring throughout the project. The project should be included in the organization's long-range planning to ensure a timely and credible completion of the project and subsequent maintenance of STDs to insure credibility with the STD users. In addition to the commitment required to build a full-featured set of STDs, the organization must invest in a comprehensive design basis document library and the software, indexing and attributing needed to support this library.

Of primary importance to the STD process is the maintenance and updates of the STDs. A controlling procedure for maintenance of STDs should establish the process and specify the update frequency. Formal STD change requests should be integral to the STD updates. The update frequency should be often enough that the STDs can be used by the customer with a great deal of faith in the fidelity of the document. A typical frequency is on an annual basis. A master schedule can be created that allows for all STDs to be updated within a year's time. This allows the STD update work load to spread out over the course of the year and eliminate peaks and valleys in the workload of theSTD writers.

Another way to maintain the STD update process is the 'on-demand' frequency. When a change is developed at the plant that would require an update to the STD, the organization generates a STD change request. When the change is actually implemented and the configuration of the plant modified, the STD organization is formally notified and the clock starts to incorporate the change request into a STD revision. A typical timeframe for such a revision is 90-days. In this manner, the nuclear organization would know that the STD is at most 90 days behind the plant configuration. This type of update process establishes credibility with respect to the content of the STD.

When documents are unavailable or reflect the design and licensing basis in an adverse way, a STD open item is created. STD open items are inconsistencies, items of incomplete information, or missing documentation identified during design bases documents development or review. Open items can be classified into three categories:

— High priority open items are items of high significance that require prompt resolution. Such issues as adverse affect on the operability of the nuclear facility or an issue related to being outside the design basis would be construed as high priority. A STD will not normally be issued with outstanding high priority open items. Medium priority open items are items of sufficient importance to require that they be tracked to closure. These open items should be entered into the corrective action programme. This ensures that these items are assigned proper owners, are screened for significance, have appropriate due dates assigned, and are tracked to closure

— Low priority open items are of low significance, are not formally tracked, and will be worked to closure as the opportunity arises. The purpose for creating the low priority open items is to flag the item for recognition. They need not be entered into the corrective action system.

The STD change request process is used to identify, control, and approve changes to the STD after initial issue. Anyone can initiate a Change Request and changes may be administrative or technical. Examples of changes include, but are not limited to, STD enhancements, licensing bases changes, modifications, and open item dispositions. It is important that plant procedures that control the change the facility identify the STDs as affected documents so that STD changes can be made as required.

VI.3. Relation to margin management

Some nuclear power plants have established configuration management committees to review design and operating margins and provide visibility to station management. In order for these committees to operate effectively, the design requirements for SSCs must be established and documented. In turn, these requirements must be compared to the actual parameters for the respective SSCs. The system description typically documents what the design requirements are. The committee can be informed on the status of the margins of various systems. They in turn can make informed decisions are made on how best to manage the available margin.

There are many ways that a ‘margin’ can be defined for a system or a component. They can include analytical margins, design margins, performance margins, operating margins, etc. For the purpose of the Margin management process, margin is defined as the mathematical difference between a limiting analysed, mandated, or calculated value (regulatory or design) and corresponding specified, measure, or proposed value (operating). Decreasing or eroding margins may be symptomatic of degrading equipment performance, operating practices, or nuclear safety awareness.

Performance indicators and metrics can be developed to provide perspective on various plant margins. Tracking the health of critical calculations using a graphics format such as colored windows has been beneficial in focusing on margins. The color of the windows can be assessed based on criteria such as the size of the margin (delta) between design requirements and existing equipment, the trend of the margin difference (delta is growing or shrinking) and the ability of the station to maintain the margin (length that the a low margin has existed).

Station organizations can use tools such as flowcharts and checklists to help engineers and planners determine if their work activity requires them to use a configuration change process. Items that are typically looked at are station controlled documents and station programmes. STDs can be used to assist personnel in the understanding on how SSCs are impacted. Training can be conducted for planners, operators, and engineers to ensure they are aware of the various configuration change processes. The training must ensure that the trainees understand the balance between design requirements (what needs to be in the plant), physical configuration (what is actually in the plant), and facility configuration information (what the documents say is in the plant).

Some organizations look at the aggregate impact of margin degradation as a part of their margin management efforts. For example, the full capability of a component includes consideration of the original design ratings and also the current materiel condition. This helps account for lost margin resulting from equipment degradation. In order to properly establish margins, engineers need to perform and review calculations and analyses. They also need to review regulatory requirements to determine the design limits for systems and components to ensure that established nuclear safety limits will not be breached. System and components specifications and requirements are established based on these calculations and analyses, and components are purchased based on these specifications and requirements. In a well designed and operated plant, systems and components operate well within their design ratings. Over time, because of equipment aging, degradation, modification, or changes to operating practices or analysis, the margin between operating and design conditions can decrease.

STDs can help establish and maintain margin management. Information in the STDs such as system and component design requirements and analytical values can be used as input to the establishment of the appropriate design data. When this information is compared to actual system and component information, the margins can be calculated. A healthy CM programme and proper maintenance of the STDs will ensure that station personnel have a good handle on their margin management programme.

VI.4. Use as roadmap to design basis document library

Experience has shown that if completed facility modifications, calculations, procedures, licensing documents, and drawings are available electronically; they will be used extensively by the staff. If available electronically, the STD can provide links to this information as well as a listing of the documents that affect the STD subject.

The roadmap function of the STDs can be constructed to provide rapid access to the design basis library. The ability to identify and access the source documents from the design basis library is vital to the STD user. The STD should contain sufficient information to allow the user to rapidly find embedded links to the source documents. The availability of source documents in an electronic form is vital to the effectiveness of the linking process.

The various STDs should serve as directories or roadmaps to the design basis document library. The larger and more comprehensive the design basis document library, the better the links can be between the STDs and the library. Because the STDs are constructed to describe the design and licensing basis, it is imperative that the library contain the appropriate and essential design and licensing basis information. One of the key pieces of the STDs are the nuclear facility calculations and analyses. While the facility safety analysis report represents the single largest source of licensing basis information, other relevant types of licensing basis information include correspondence with the regulators and correspondence related to the facility operating licence.

Calculations best define the design basis and the design requirements imposed on the subject covered by the STD. Experience has shown that calculations are the documents most accessed in the design basis document library. Direct links between the STDs and the calculations allow the user to access the design requirements quickly. A major challenge with the calculations in the library is maintaining an accurate status. Unless the configuration management of the calculations is tightly controlled, there is the potential for inaccurate status of the calculations (active, superseded, etc.). Because there is no indication that a calculation is superseded on the document itself, the calculation index must accurately reflect the status.

The facility SAR is the principal document containing licensing basis information. Links between the SAR and the STDs are inherent in the proper depiction of licensing basis information. Linking to other licensing basis information such as correspondence with the regulator is more difficult to accomplish but equally important. Included in this correspondence are any commitments that affect the design basis.

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GLOSSARY

business continuation plan: Plan for the IT organization to re-establish IT services and protect or restore data to continue delivering IT services after a natural disaster, fire, explosion or DOS event; also known as ‘disaster recovery’.

commitments: Statements made in formal correspondence such as responses to regulator bulletins, letters, and enforcement actions, as well as commitments contained in safety evaluations or licensee event reports. Commitments may be superseded by later commitments or correspondence, or by properly implemented changes in plant configuration.

configuration management: The process of identifying and documenting the characteristics of a facility’s structures, systems and components (including computer systems and software), and of ensuring that changes to these characteristics are properly incorporated into the facility documentation.

controlled documents: Documents whose content is maintained uniform among the copies by an administrative control system. The goal of controlling documents is to ensure that work is performed using approved current information, not obsolete information. Important documents to be controlled are uniquely identified (including revision number, date, and specific copy number), and distribution is formally controlled. Revisions to controlled documents are uniquely tracked and implemented, including mandatory page replacements and receipt acknowledgment. Controlled documents typically include procedures for operations, surveillance, and maintenance, and safety basis documents such as the SAR, and hazard and accident analyses.

design basis: The range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits by the planned operation of safety systems.

design basis functions: Functions performed by systems, structures and components (SSCs) that are (1) required by, or otherwise necessary to comply with, regulations, licence conditions, orders or technical specifications, or (2) credited in licensee safety analyses to meet regulatory body requirements.

design basis values: Values or ranges of values of controlling parameters established as reference bounds for design to meet design bases functional requirements. These values may be (1) established by regulatory body requirement, (2) derived from or confirmed by safety analyses, or (3) chosen by the licensee from an applicable code, standard or guidance document.

design control: Measures established to ensure that the information from design input and design process documents for structures, systems, and components is correctly translated into the final design.

design input: Those criteria, parameters, bases or other design requirements upon which detailed final design is based.

design process: Documented design practices such as calculations, analyses, evaluations, technical review checklists, or other documented engineering activities that substantiate the final design.

design requirements: Technical results of the engineering design process for specific systems, structures, and components that specify required performance values. Design requirements are typically defined in design output documents (such as drawings and specifications) and may be expressed, for example, as capabilities, mechanical or electrical capacities, physical dimensions, or temperature or pressure limits.

discrepancies: Those open items identified by design bases programme activities that are confirmed discrepant and may have potential safety significance.

engineering design bases: The entire set of design constraints that are implemented, include those that are (1) part of the licensing bases and form the bases for the regulator's safety judgment and (2) those that are not included in the licensing bases but are implemented to achieve certain economies of operation, maintenance, procurement, installation, or construction.

engineering design process: The technical and management process that begins with the identification of design inputs and constraints (e.g. mission objectives, commitments, applicable codes, standards, regulations, procedures, and methodologies), processes this information, and results in the issuance of requirements. This process defines and documents the inputs; adheres to the constraints; performs and documents the necessary analyses, calculations, technical studies and evaluations; and ensures the outputs of the process (i.e. the requirements that dictate a design that satisfies the inputs and constraints) are documented and complete.

enterprise resource management: Term used to describe the accounting, general ledger and asset management solutions for nuclear power plant equipment, parts, labor, contract and project costs. Although not considered to directly support configuration management, ERP software is normally connected to the MRO solution to provide a complete nuclear power plant and utility enterprise business solution.

facility configuration information: Record information that describes, specifies, reports, certifies, or provides data or results regarding the design requirements or design basis, or pertains to other information attributes associated with the facility and its structures, systems and components. This information may be contained in original hard media, film, paper, magnetic tape, electronic media or other sources of information used to make sound technical decisions regarding procurement, modification, operation and maintenance of the facility.

final design: Approved design output documents and approved changes thereto.

Licensing Basis:The set of docketed documents and commitments, and other documents such as the SAR, operating licence. The plant's licensing basis includes all applicable requirements of design basis. Can also be stated as the set of requirements that includes the applicable regulations and licensee commitments that ensure the unit's operation is in conformance with the operating licence, the unit's design bases as specified in regulations and the unit's SAR.

maintain, repair and overhaul: General term used initially to refer to maintenance management processes in nuclear power plant's, but now refers to all software supporting nuclear power plant functionality and business rules in an enterprise nuclear power plant CM solution. Is sometimes renamed 'maintenance resource optimization' to reflect the increased scope of users, processes and data involved in enterprise CM solutions supporting nuclear power plant operation.

margin: The mathematical difference between a limiting analysed, mandated, or calculated value (regulatory or design) and a corresponding specified, measured, or proposed value (operating). Margin may be expressed in engineering units or as a percentage value.

open items: Any inconsistency, item of incomplete information, or missing documentation identified during design bases document development (i.e. preparation, review, verification, and validation), or other deficiency that requires a disposition.

review: The process of reviewing, confirming, or substantiating the DBD by one or more methods to provide assurance that the DBD meets the intended requirements.

safety-related: The term applied to plant systems, structures, components, and related activities relied upon to remain functional during and following design basis events to ensure (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut down the reactor and maintain it in a safe shut-down condition, (3) the capability to prevent or mitigate the consequences of an accident that could result in potential offsite exposures in excess of guidelines.

service level agreement: The software, services and support expectations included in contracts with software or systems service providers. Terms can vary by the circumstances and product, but generally include duration of service, software upgrades to be included in contract, required operability rates and outage response times, security and DOS expectations.

service-oriented architecture: An IT strategy where significant or all enterprise nuclear power plant business function solutions are provided and maintained by a third party, including software, hardware, data and business functionality. Similar to BPO but more comprehensive in scope, service, SLA and responsibility.

system and topical descriptions: The summary of system or topical information that relates to the nuclear power plant's design basis and design basis information. These documents serve to delineate the design intent and either directly incorporates the related design documentation or represent a directory (roadmap) to related design documentation (e.g. calculations and analyses) and licensing documentation.

system and topical description open items: Any inconsistencies, items of incomplete information, or missing documentation identified during Design Bases Documents development (e.g. preparation, review, verification, and validation), or general use that requires a disposition. Those items that are discovered during the implementation of design bases programme activities that are potential discrepancies and require disposition.

system and topical description owner: The person or department responsible for the maintenance and technical content of the STD. Any cognizant party can initiate a change to a STD. The STD owner maintains the process for creating and updating the STD as well the development and maintenance of the actual document collection.

system and topical descriptions validation: Process that provides reasonable assurance that design basis information is consistently reflected in the physical facilities and those controlled documents used to support facility operations.

system topical description verification: The process of checking that the information contained in the design bases documents has been correctly and consistently translated from the source documents.

support system: A system that provides a supporting service to another system that is necessary for the supported system to be capable of meeting its system requirements. In some cases the operability of the supported system cannot be established if the supporting system is not operable.

supporting design information: The substantial set of detailed design information underlying the design bases, including other design inputs, design analyses and design output documents. Supporting design information may be contained in the SAR (as design description) or other documents either docketed with regulator or retained by the licensee.

system: An interrelated set of structures, equipment, subsystems, modules, components, devices, parts, and/or interconnecting items that is capable of performing a specified function or set of functions that fulfil a purpose. Systems usually have defined physical boundaries, and systems often depend upon human interactions. Some aspects of a system might be important to safety or programmatic mission, while others might not. Sometimes a distributed set of individual structural elements may be considered collectively to be a system. Accordingly, the term 'system' is used in this standard to fully encompass structures, systems, and components (SSCs). A system design description may be appropriate even if a particular set of items does not meet this definition.

ABBREVIATIONS

ACT	action tracking
AML	approved model list
AQR	augmented quality related
ASME	american society of mechanical engineers
BOM	bill of materials
BPO	business process outsource
CAD	computer-aided design
CADD	computer-aided drafting/design
CAE	computer-aided engineering
CAR	corrective action request
CM	configuration management
DASD	direct-access storage media
DB	design basis
DBD	design basis documentation or design basis document
DCN	design change notice
DCR	document change request
DCS	document control system
DMS	data management system
DOS	denial of service
DTL	document type list
DUR	data update request
ECC	engineering change control
ECM	enterprise content management system
EDMS	electronic document management system
EDR	engineering design review system (content manager)
EMP	employee ID

EQAR	environmental qualification assessment report
ERD	entity relationship diagram
ERM	enterprise resource management
ERP	enterprise resource planning
EULA	end user license agreement
FCR	facility change request
FIN	financials
HVAC	heating, ventilation and air-conditioning
IDE	integrated development environment
IEE	item equivalency evaluation
IEEE	institute of electrical and electronics engineers
INPO	institute of nuclear power operations
IP/VPN	internet protocol virtual private network
ISI	in-service inspection
IT	information technology
LAN	local-area network
LCO	limits and conditions for operation
MCR	master control room
MEL	master equipment list
MMS	materials management system
MOV	motor-operated valve
MR	material request
MRO	maintain, repair and overhaul
NEI	nuclear energy institute
NRC	nuclear regulatory commission
NSR	non-safety related
NSSS	nuclear steam supply system

OCR	optical character recognition
PDMS	plant design management system
PIS	plant information system
PLM	plant lifecycle management
PUR	purchasing
QA	quality assurance
QC	quality control
QRM	quality records management
RAID	redundant array of independent disks
RM	records management
RPA	radiation work permit authorization module Code (system name: RWP is the actual paper form)
RTL	records type list
RWP	radiation work permit (form)
SAAS	software as a service
SAR	Safety Analysis Report
SCADA	supervisory control and data acquisition
SLA	service level agreements
SOA	service-oriented architecture
SQA	software quality assurance
SR	safety related
SSC	structures, systems and components
STD	system and topical description
TCO	total cost of ownership
UFSAR	updated final safety analysis reports
USNRC	United States Nuclear Regulatory Commission
UTC	uniquely tracked commodities

V,V&C	verification, validation and certification
WAN	wide-area network
WBS	work breakdown structure
WM	work management
WMA	work management system module code (or WMS for system)
XML	extensible mark-up language

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