LICENSED BASES MANAGEMENT FOR ADVANCED NUCLEAR PLANTS

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Prospective Advanced Nuclear Plant (ANP) owners must have high confidence that the integrity of the licensed bases (LB) of a plant will be effectively maintained over its lifecycle. Currently, licensing engineers use text retrieval systems, database managers, and checklists to access, update, and maintain vast and disparate licensing information libraries. This paper describes the demonstration of a "twin-engine" approach that integrates a program from the emerging class of concept searching tools with a modern Product Data Management System (PDMS) to enhance the management of LB information for an example ANP design.

Background

Operating nuclear plants have experienced difficulties in maintaining complete integrity of their LB information. The complexity and size of the LB, the continual process of making improvements to the LB, and the lack of adequate tools and capabilities to deal with the text and data in the LB have contributed to the difficulties of comprehensively maintaining the LBs of operating plants. For some plants, the U.S. Nuclear Regulatory Commission (NRC) has required resolution of certain LB issues as a prerequisite to renewed operation. Owners of future plants will require a comprehensive approach for ensuring LB integrity at a high confidence level and in a cost-effective manner consistent with a competitive economic environment for producing electrical power.

The current LB of an ANP starts with the top level documents approved by the NRC such as the Standardized Safety Analysis Report (SSAR), the Probabilistic Risk Assessment and Technical Specifications. These documents are linked to the design data through structure, system, component specifications and other documents, as well as programmatic topics. During construction and throughout the operating and maintenance phase, modifications to the plant are made, new regulatory requirements come into effect, and other perturbations will occur. These changes have the potential to change the LB of the plant. These changes must be identified and reviewed to ensure that the LB of the plant is not changed without the review and safety evaluations as required by NRC regulations.

The nuclear industry's legacy of hard copy or image configuration management has significantly impacted costs and quality. Managing documents as opposed to managing the underlying data has led to:

- Errors and regulatory violations from inability to retrieve design and licensing data
- Lack of confidence that all data is at hand to evaluate a design or licensing issue
- Costs for document retrieval, storage, maintenance, and data reconstitution
- Reliance on engineering "tribal knowledge"
- Conflicting information among different sources and ensuing costs of resolution

Existing Information Management Practices

Since the earliest days of nuclear power, licensees accomplished their work in segmented domains such as construction, analyses, and design record keeping without automating the underlying links between the actual plant configuration and the documents that specified the configuration. This approach was also fostered by the use of standalone engineering tools that provide a single perspective for design control. With increased regulatory oversight, many owners responded by adding layers of programs to augment the management of the original design. These layers represent added complexity and require additional staff.

The configuration management process for an ANP must ensure complete consistency at all times between the physical plant, plant design and implementing documents, and the LB. An integrated IMS for nuclear power plants encompasses all data and information for all phases of the plant life cycle including design and licensing, construction, testing, operations and maintenance, deactivation and decommissioning. Management of the LB has been selected for consideration in this project because of its criticality and because of the present lack of a comprehensive solution for future nuclear plants.

Figure 1 illustrates the situation at many nuclear plants wherein different representations of the plant and its licensed bases exist. A small sample of the information flows is also illustrated to highlight the interrelationships that must be managed. These separate domains exist and when reconciled with legal requirements, maintaining these separate views in a congruent manner is both expensive and an undesired source of risk.

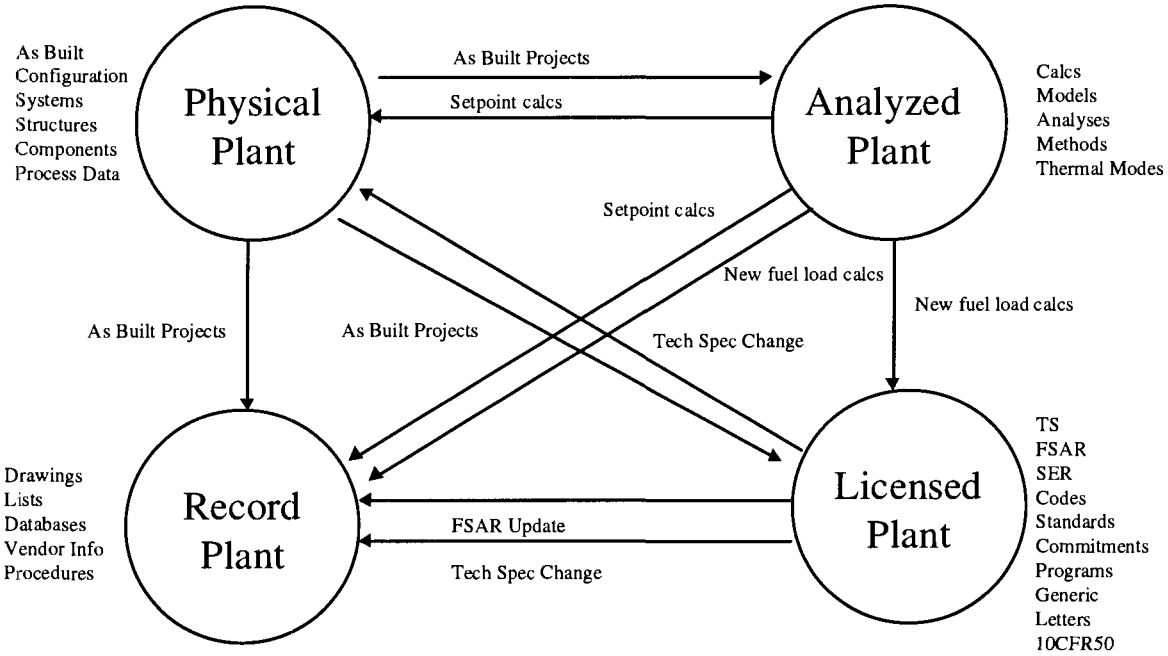

Figure 1. Design Control Interfaces

Fundamental to the Advanced Information Management System (AIMS) design is the concept of maintaining the links between design and text documents and engineering parametric data. For simplicity, the depiction of the plant simulator and the plant operating procedures has not been illustrated, but these views also represent key bases of knowledge to support plant operations that must be maintained consistent with the plant's licensed bases. Therefore, AIMS represents a methodology to link the different views in a rigorous and cost effective manner as show in Figure 2.

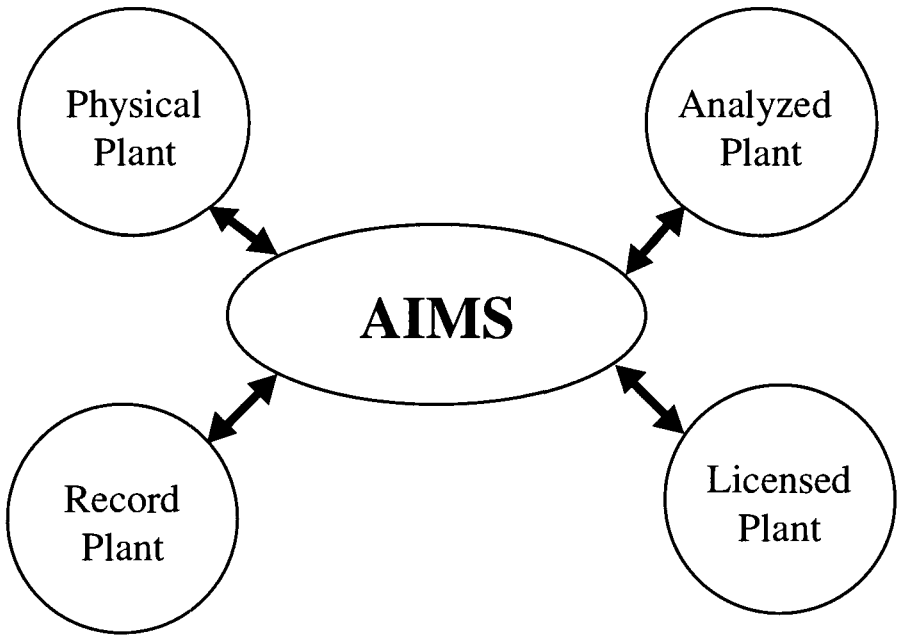

Figure 2. AIMS Design Control Interfaces

Proof of Approach Description

A state-of-the-art PDMS, eMatrix™ from MatrixOne, Inc. (www.matrixone.com), found commonly in the manufacturing sector to manage equipment design bases, has been integrated with an advanced concept search engine, CCM™ (Contiguous Connection Model) from Applied Technical Systems, Inc. (www.apptechsys.com), to form the basis for Advanced Information Management System - Licensed Bases (AIMS-LB)[1]. The resulting system provides an information management environment as well as data searching, accessing, and learning capabilities for the LB information of an ANP design. The project team loaded LB information from Westinghouse Electric Company's System 80+™ design into AIMS-LB and used it to demonstrate a safety review process for determining if NRC approval would be required to make a specific example design change.

The proof of approach architecture in Figure 3 shows a high-level view of how the two applications are integrated with plant information and accessed by a "thin client" (Microsoft Internet Explorer web browser). The proof of approach included functional aspects of eMatrix™ and CCM™ to make it possible to perform advanced text searches of LB documents and demonstrate the significant advantages of the twin engine approach. In the proof of approach example, the eMatrix™ application serves as the main AIMS application which calls the CCM™ application as needed. The user does not see a difference in switching applications since the web browser interface provides a common look and feel.

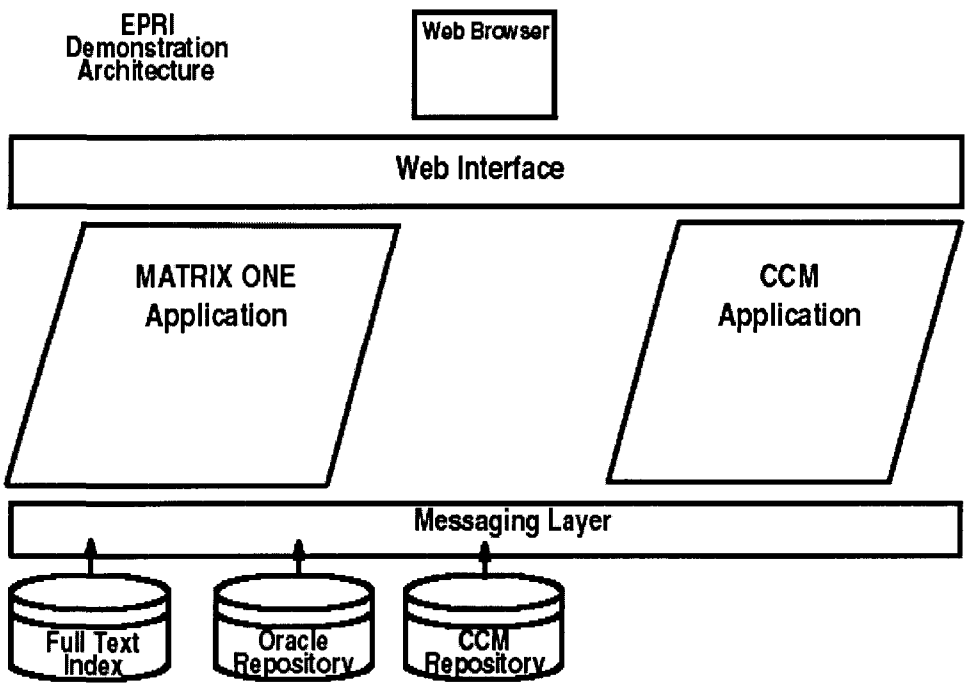

Figure 3. Conceptual Proof of Approach Architecture for the AIMS-LB

The functional aspects of eMatrix™ provide enterprise-wide and business-to-business collaboration of information. eMatrix™ can create and manage a distributed repository of complex and diverse information as well as store and provide access to data generated by most applications used in business. eMatrix™ also contains a full set of features to manage everyday business practices such as control and expedite data access, approval and release, notification, supply management, and reporting.

CCM™ has the ability establish relationships as data is viewed and manipulated compared to the traditional approach of predefining keywords or links. CCM™ learns relationships as a user investigates the data. Thus, the necessity to establish and maintain all possible relationships in a complex schema before hand is eliminated. This is regarded as a major productivity improvement opportunity.

Twin Engine Searches

The twin engine concept (integration of a PDMS and concept search engine) to enhance text searches is the core feature of AIMS-LB that differentiates it from other LB management tools. An explanation of how the twin engine concept improves searches is illustrated in Figure 4. eMatrix™ defines the entire plant in a hierarchical relationship such that a specific system, structure, component, or topic (SSCT) can be identified by "drilling down" through the eMatrix™ logical model. The concept search capability of CCM™ provides the ability to search for all instances of a concept across the entire spectrum of SSCTs. The intersection of these two types of searches yields more comprehensive and accurate results than a search by either one of the types.

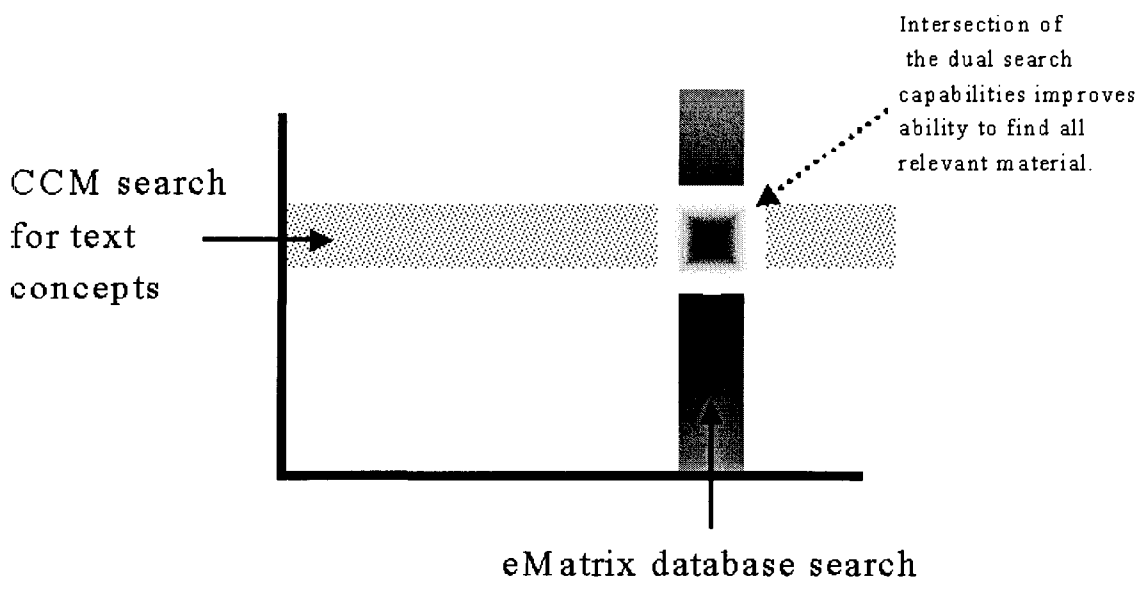

Figure 4. Twin Engine Search Concept

Licensed Bases Electronic Information

Over 4000 electronic files for the System 80+™ LB were provided for inclusion in the AIMS-LB database. These files contain the SSAR, Design Certification Document (DCD), Safety Evaluation Report (SER), Technical Specifications and documents specific to the Chemical Volume and Control System. Many of the large documents consisted of files for each chapter plus additional files with drawings or figures.

The files were in a number of different formats such as: MS Word, Word Perfect, Envoy, PDF and PCX. CAD files were not available, all drawing files contained image data prohibiting extraction of ASCII text information for indexing. Additional electronic information was downloaded from the NRC web site. This information included the Code of Federal Regulations (CFR) Title 10 Energy and a number of NUREG documents in HTML and Word Perfect formats.

A schema, organized by Systems, Structures, Components and Topics, was designed and implemented in the PDMS software to provide a bases for incorporating the System 80+™ documentation and technical data. Figure 5 illustrates a typical component data sheet in eMatrix™.

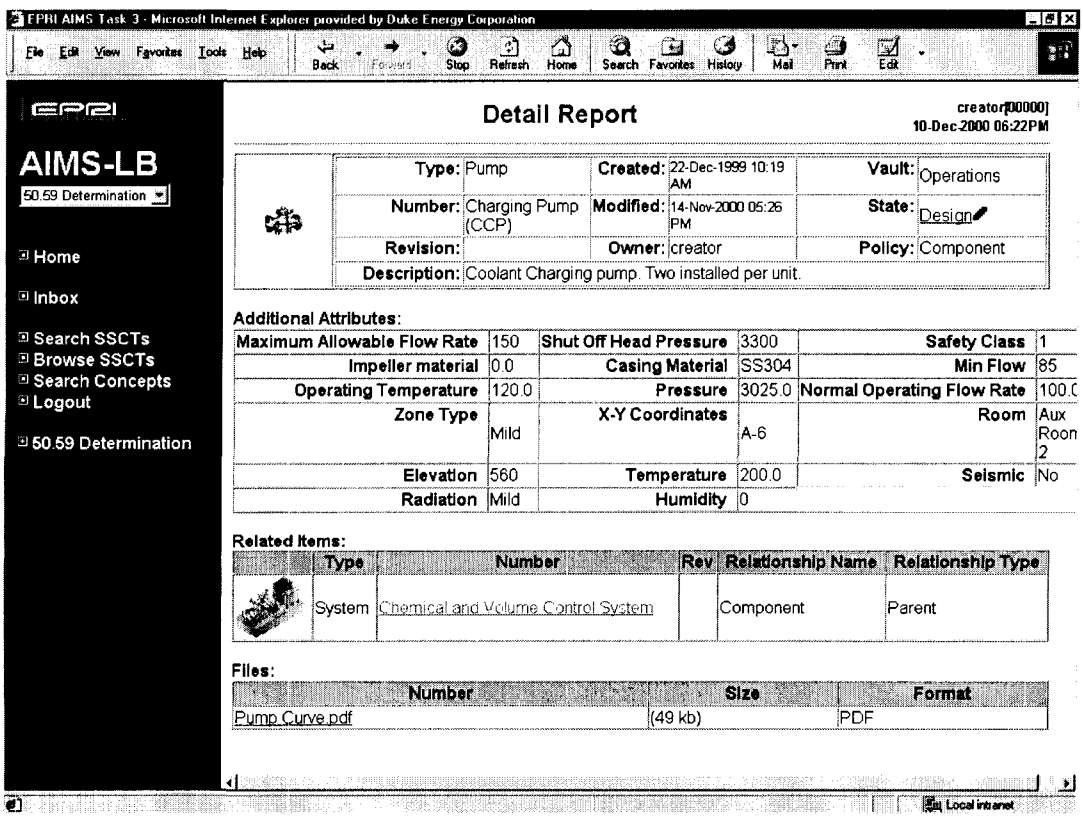

Figure 5. Charging Pump Data Sheet in AIMS-LB

AIMS-LB User Interface

Figure 6 shows the initial window presented once the AIMS-LB application is started. The AIMS-LB user interface is provided by a standard web browser and includes the standard functional buttons in the top horizontal banner. The menu below the buttons in the left-hand frame lists the various tasks that comprise the safety review process while the right-hand frame provides the work area for the selected task. The left-hand frame provides a continuous point of reference for supporting user navigation as browser windows are opened and closed.

The menus will appear and disappear depending on the selection of the drop down box located immediately under the AIMS-LB label. The Search SSCTs, Browse SSCTs and Search Concepts selections are operational at all times and permit ad hoc queries of the eMatrix™ database or concept searches of the text documents.

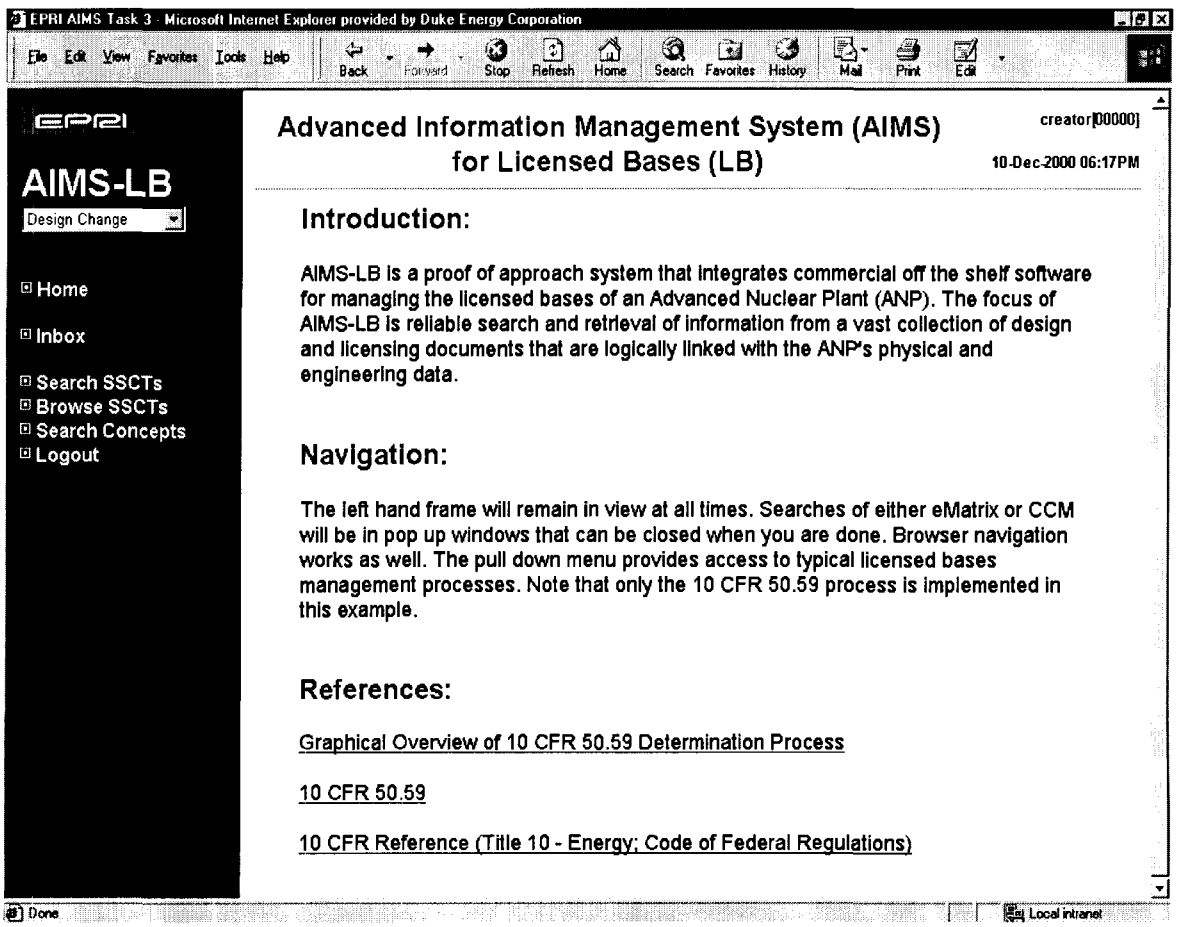

Figure 6. Navigation Menu and Package Review

AIMS-LB Scenario

The objective of the proof of approach version of AIMS-LB was to show a scenario that would aid licensing engineers to more efficiently and completely perform their duties. The work activities depicted by the information and screen shots in this section describe portions of the process that licensing engineers use to perform

safety reviews of proposed changes at a plant. The final product from this process is a determination as to whether the NRC's permission is required prior to implementing a proposed change, of any type. This scenario was chosen since it tests all aspects of LB management.

In Figure 7, a licensing engineer has selected a particular design change for a safety review and has obtained a "50.59 Report" which documents the current state of the safety review. This report is maintained continuously by the software and tracks the status of who is performing the work and when it is completed.

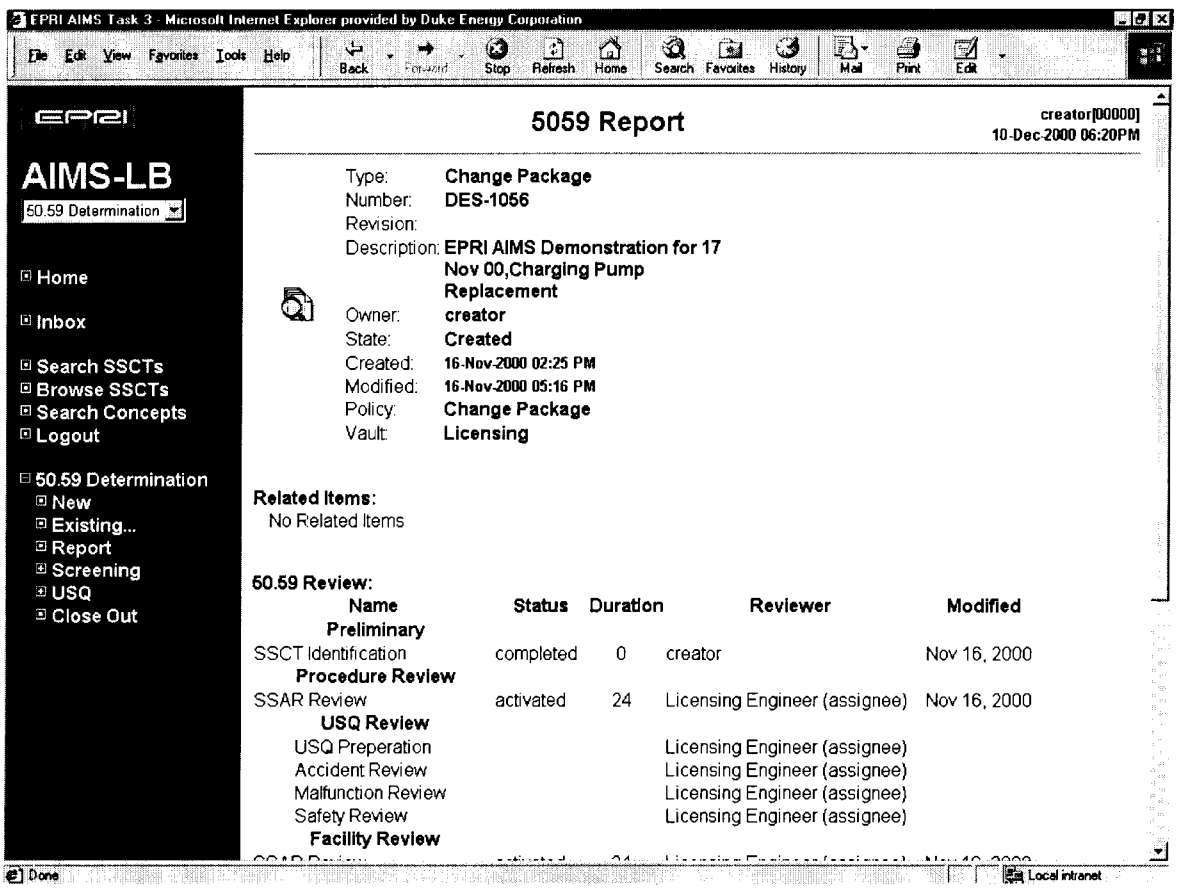

Figure 7. Status of Safety Review Process

After the preliminary steps are complete, users are led through reviews of the SSAR, potential accidents and malfunctions and a safety review. The user answers a series of detailed questions for each aspect of the review, often obtaining information from the LB and performing analysis to answer the questions.

After completing the reviews, the user finalizes the process by dispositioning all documents that have been reviewed and all information provided by users. After this step, the user can make a final assessment regarding the need for NRC approval before implementing the change. Once this is completed, the report of the review is published and the next step in the change process is initiated by providing notification and report access to other reviewers and plant management.

Numerous AIMS-LB features support the safety review process described previously:

- Sign-In and User Access
- Navigation and Work Status
- Search and Retrieval
- Work Flow
- Shopping Cart for Documents
- Document Disposition
- Audit Trail
- Publication and Notification

A key focus of AIMS-LB, search and retrieval of LB information, is accomplished by a twin engine approach. This approach provides a traditional database capability as well as a concept search engine for ensuring all relevant text information and relationships are accessed. The next sections describe these features.

Search and Retrieval of Structured Data

The eMatrix™ database provides a structured organization of the plant information as a series of objects related by their logical and physical characteristics. The starting point of a query about a particular system or component, is to retrieve a listing of the specified objects and then "drill down" into the object oriented database.

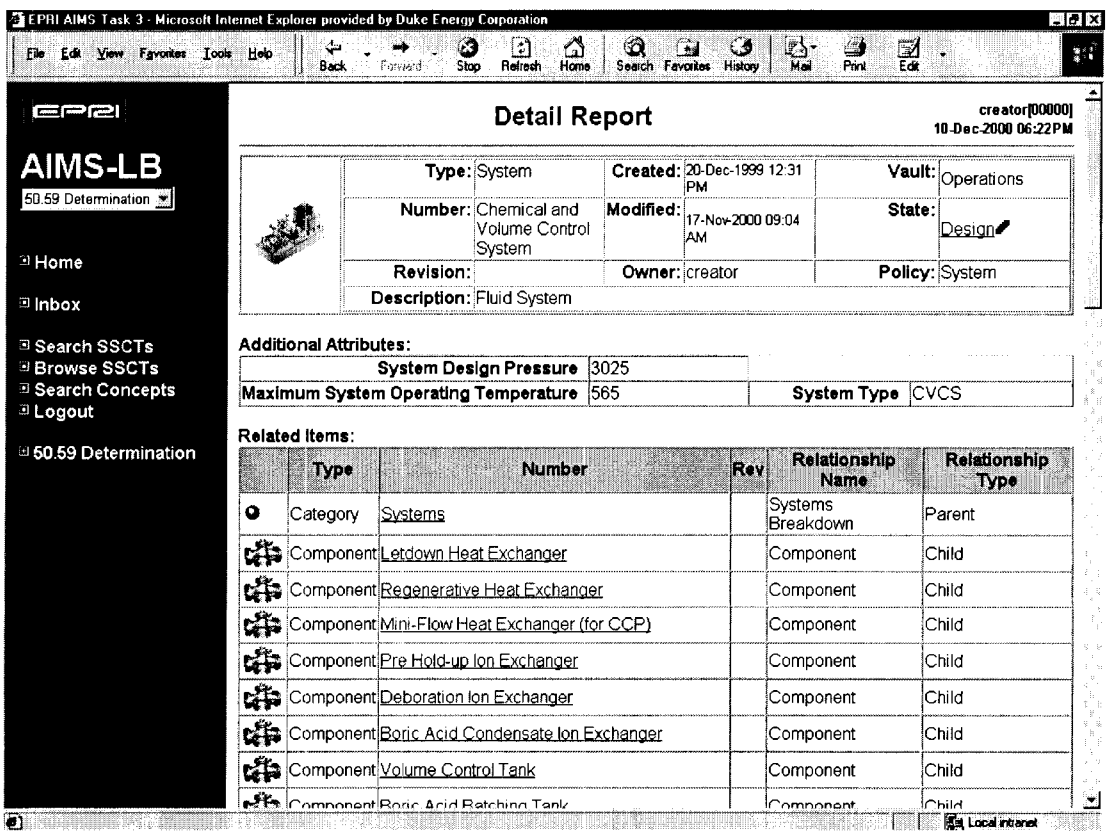

Figure 8. System Information Retrieval Using eMatrix™

Figure 8 shows a report generated in response to a search for the Chemical and Volume Control System. The search yields a listing for the system including parameters and components of the system. Each of the components shown in Figure 8 can be queried to bring up a description of the component as shown in Figure 5. AIMS-LB uses the PDMS for the management of all structured data.

Search and Retrieval of Unstructured Data

Much of the LB is text information that must be word searched or summarized with keywords. However, there are significant language limitations that hinder standard text search engines and the subrogation of documents by keywords. Concept searches enable complete searches of the LB to look for information that would otherwise be hidden due to the use of different words for defining a concept, misspellings and other issues associated with text information. The retrieval of text information must accommodate changing terms and language over time and among sources. For example, "main steam line" is the same concept as "main steam pipe".

Performing twin searches ensures that all the relevant information is retrieved from the LB to support the required activities. Once specific information is obtained from a concept search, it can be added to the database to ensure it is stored in or linked to other objects for future access.

In Figure 9, the user is given a starting point for searches with a list of terms derived by CCM™ from the System 80+™ documentation. The user selects starting words from the list organized either by alphabetic listing or by frequency of occurrence.

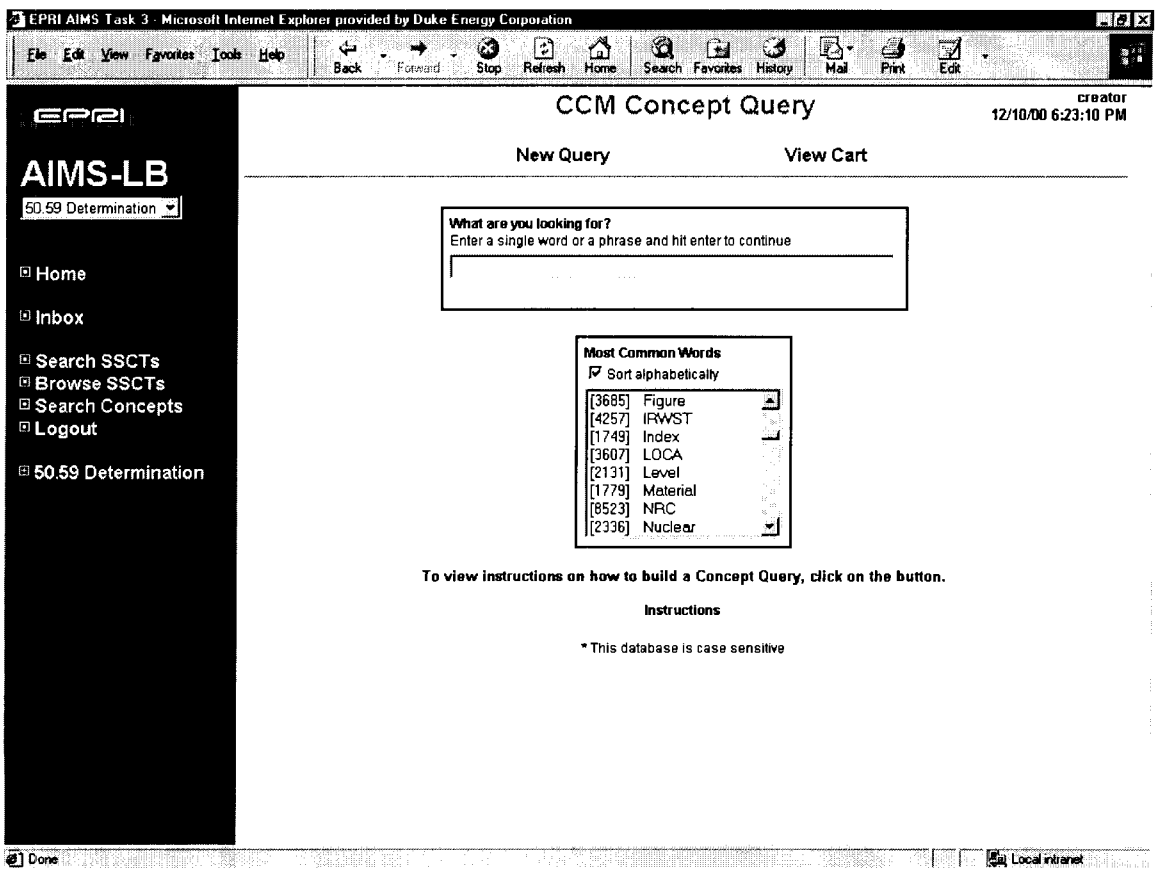

Figure 9. Concept Query Starting Point

Once the query has started, CCM™ presents lists of words, as shown in Figure 10. These list are all the words from the entire set of text documents that could be the logical "next" word or logical alternatives (due to misspellings and other variations in the text that has been indexed). In this manner, the user selects the words of interest to form the concept for the search and then executes the query.

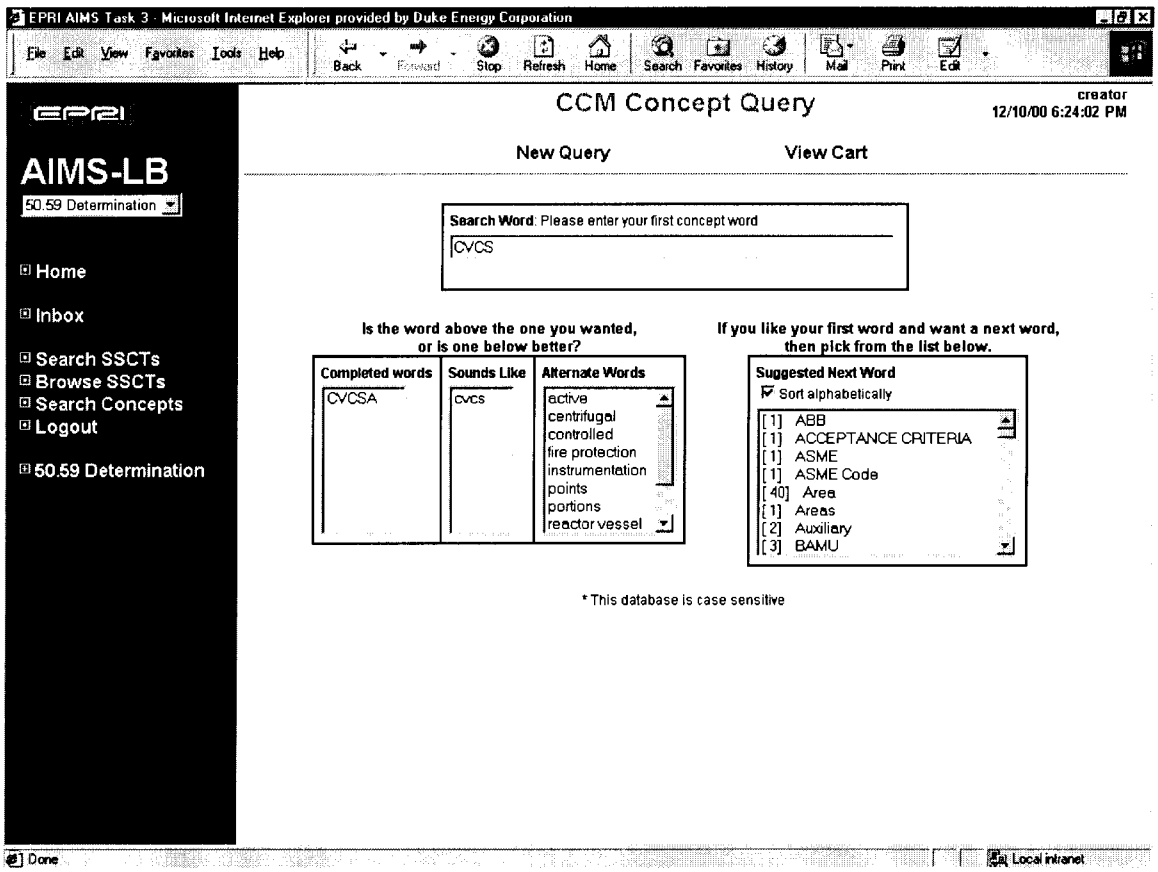

Figure 10. Expansion of CCM™ Query to Build a Complete Search

Not shown in this limited set of examples is the expansion of the query to a three word string. Additionally, the ability to expand queries to alternative words that CCM™ has evaluated as similar or related to the query words is not illustrated. Other CCM™ features to find similar documents, based upon analysis of a retrieved document have also been implemented to augment the search capabilities.

In summary, CCM™ provides a robust method for handling unstructured information such as the large quantities of text information typically found in the design and LBs for nuclear power plants. Given the continuing trend towards creation and storage of large amounts of text in electronic form, concept searching is needed to comprehensively review LB information for the foreseeable future. Eventually, the use of emerging industry standards such as the eXtensible Markup Language (XML) may provide a means of logically relating information inside text documents.

Figure 11 illustrates a document that has been selected from a list of documents retrieved by CCM™. An automatically generated summary or "gist" of the document is produced for the user to screen. The user can review the summary and then retrieve the full document as hosted by its native application if desired.

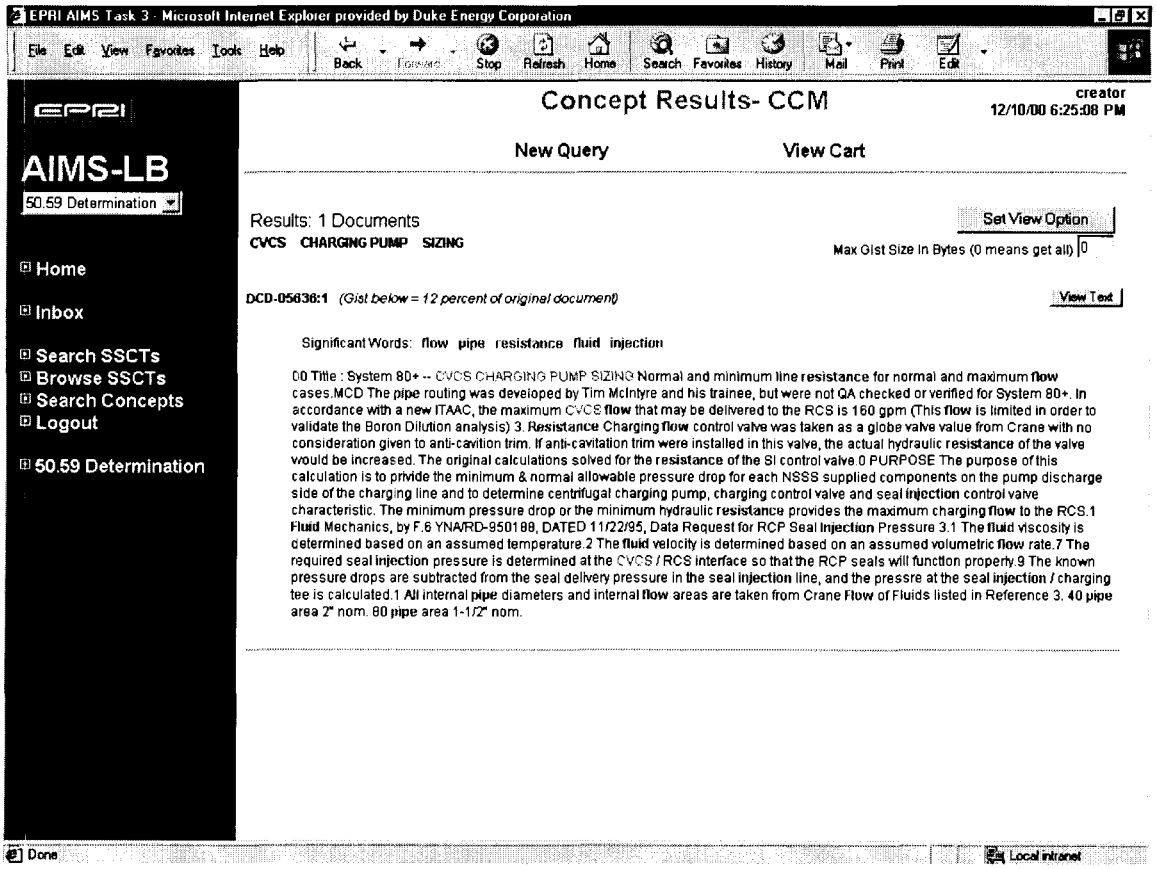

Figure 11. Retrieval of Document Gist

Conclusions

The proof of approach is a small scale but focused effort to assess emerging technologies for managing unique aspects of the LB, such as the large and diverse amount of text information that needs to be logically linked to the plant physical and engineering data. Results of this work indicate that ANPs should consider using a PDMS as a basis for their plant design-related information. The ranges of capabilities, scalability, and flexibility of modern PDMSs appear to make them directly suitable for these applications. In addition, emerging concept searching tools can be used in conjunction with PDMSs to deal with the ambiguity inherent in text information. The twin engine approach also "learns as it goes" by turning recently exercised concepts into key words, thus scaling up its capabilities with ever growing and more complex LBs over the life of the plant.

Reference

[1] *Management of the Licensed Bases of Advanced Nuclear Plants: Proof of Approach*, EPRI 1000056, September 2000.