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AN INTEGRATED INVENTORY INFORMATION MANAGEMENT SYSTEM

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Abstract
Since the end of the Cold War, the focus of the Department of Energy (DOE) Defense Programs (DP) has shifted from developing and producing new weapons to the maintenance and stewardship of a much smaller stockpile. This change of focus--along with the downsizing of the nuclear weapons complex, reduced budgets and the initiation of stockpile rebuild activities--has created a challenging set of circumstances under which nuclear materials and special non-nuclear materials must be managed. To address the challenges associated with managing these materials and reliably forecasting future national security needs, Sandia National Laboratories is working with DOE/DP and other DOE laboratories and plants to define an Integrated Inventory Information Management System (IIIMS). This paper will describe the general architecture and the capabilities of the IIIMS that have been identified to date and discuss the proposed approach to system development.

Introduction
Over the past 40 years DOE/DP has developed a number of inventory systems to manage the various stages of nuclear weapon development, procurement, production, testing, and maintenance. To date, these systems have performed the functions for which they were designed. However, over the past several years the number of operational weapons in the active inventory has been reduced resulting in a greater materials management responsibility. Also, as the weapons, materials, and facilities age, budget restraints require more precision in planning and forecasting to accomplish the Department's missions.

To address these new challenges, Sandia National Laboratories has proposed the development of an Integrated Inventory Information Management System (IIIMS). In the past decade, the state of computer science has advanced beyond traditional transaction-based computer systems to analysis based systems that support the decision-making process in addition to automating record keeping. Large corporations now routinely make use of information systems to assist in the analysis and planning of decisions at the enterprise level. These tools and techniques should be helpful in assisting DOE/DP in its weapons material stewardship mission. A major goal of the IIIMS project is to

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demonstrate the benefits of an enterprise-wide information system for DOE/DP. This paper describes the architecture, features, and functions of an IIIMS.

Background

Over the past five years, Sandia National Laboratories has been working on the integration of material management technologies to create a comprehensive materials management capability. Through these efforts Sandia has developed a materials management integration architecture based on the Zachman Framework for Enterprise Architecture planning model [1]. The architecture has three levels: enterprise, site, and room/building. The Enterprise Materials Management architecture is shown in Figure 1.

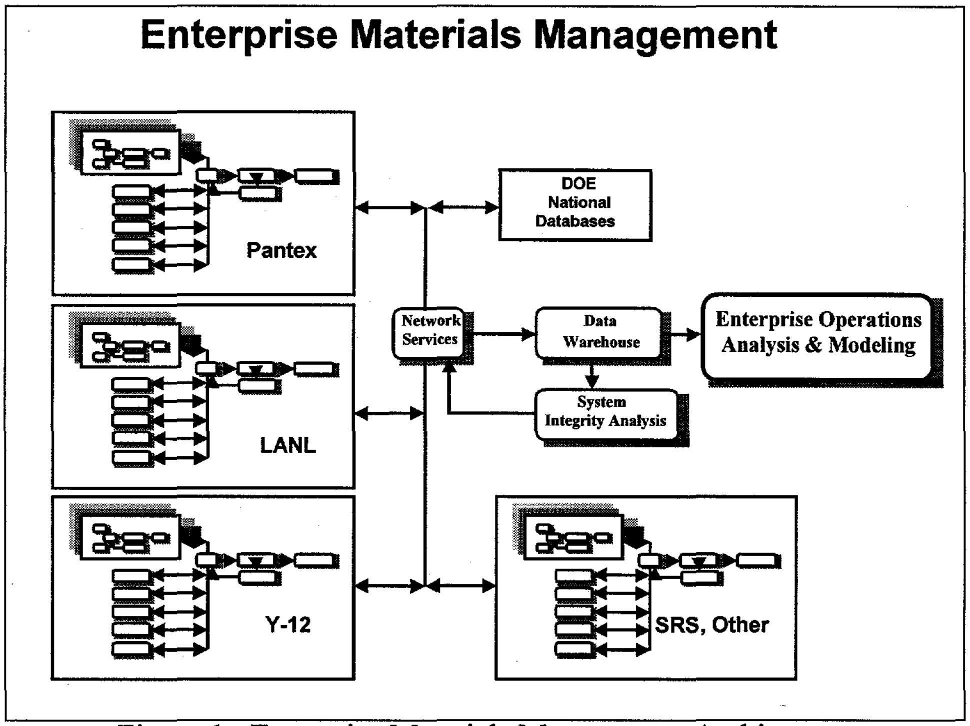

Figure 1: Enterprise Materials Management Architecture

The goal of the Enterprise Materials Management architecture is to provide an advanced inventory information system that provides the user with analysis and modeling capabilities to make accurate and timely decisions necessary for the management of nuclear materials and special non-nuclear materials. This goal is realized in the architecture's Enterprise Operations Analysis and Modeling module. The materials data required for the Enterprise Operations Analysis and Modeling will be acquired from DOE national nuclear material databases, DOE forecasting, scheduling, and transportation databases, and the DOE/DP sites. The Network Services module supplies all the services required to deliver the data to the Data Warehouse. The Data Warehouse is where the data are stored in a format appropriate for retrieval and analysis. The System Integrity Analysis module evaluates the data for consistency, duplication, and other discrepancies associated with merging disparate data from multiple sources.

To meet the goals of this project, information of interest to DOE/DP will need to be obtained from the site systems in an efficient and timely manner. This will require each of the sites to implement an architecture similar to the Enterprise architecture. The Site Materials Management architecture is shown in Figure 2.

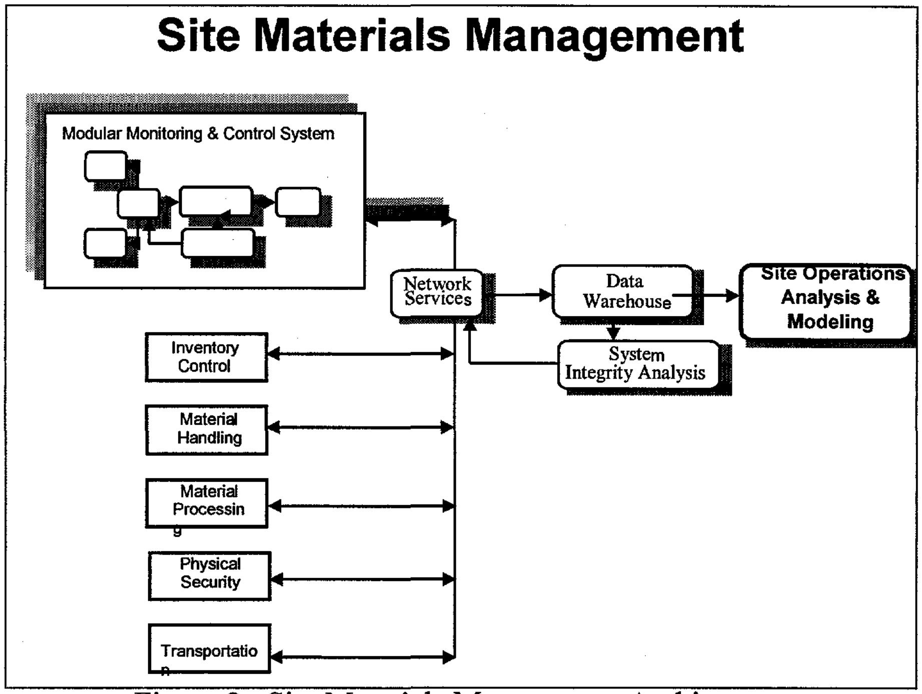

Figure 2: Site Materials Management Architecture

The same basic modules that appear in the Enterprise architecture model are required in the Site architecture: Site Operations Analysis and Modeling, Data Warehouse, Site Integrity Analysis, and Network Services. The monitoring, inventory control, material handling, material processing, physical security, and intra-site transportation systems are the site level systems that have the data necessary for Site Operations Analysis and Modeling. The Site Operations Analysis and Modeling module would supply the data required for the Enterprise level analysis.

Implementation of the Site level architecture would provide the DOE/DP sites with a system that will also support their operations and modeling needs. To assure this objective is met, site representatives will be involved throughout the entire lifecycle of the project. Our project team is working to map the material management and inventory accounting systems from several sites onto this architecture. We are also investigating the requirements for operational analysis and modeling at both the enterprise and site level.

The lowest level of this architecture, the Monitoring and Control System module (Fig. 2), is focused on monitoring systems for inventory control and accountability, safety, security, or international safeguards within a specific room, magazine, or building. It is expected that the underlying features of the architecture at this level will be site-specific and development as such is not a specific objective of the Integrated Inventory Information Management System project.

This project will utilize existing systems at the enterprise level (e.g., NMMSS, NMIA) and at the site level (e.g., LANMAS) to obtain the required data. Existing data systems and their contents will be surveyed to determine their capability to collaborate and share necessary data. Enhancements and new system development activities will be carefully evaluated in terms of their costs and benefits. To reduce development costs, this project will use tools already developed by the information technology community and in use by major corporations to support their analysis, planning, and decision making.

Initially, this project will be limited in scope to the following materials:

- ^{239}Pu
- HEU, Depleted U, Natural U
- Lithium, Tritium, Deuterium

Once DOE/DP users have a system to support accurate and timely decisions for the management of these materials, the architecture can easily be expanded and scaled to incorporate other materials of interest to DOE/DP.

Approach

The approach to the development is business-driven rather than technology-driven. A business-driven implementation stresses understanding the context in which the information system will be used. Experience has shown that many software development efforts fail because they do not adequately account for the "corporate culture" and the associated unstated issues. A more "holistic" approach to software development, which considers the development effort from many different viewpoints, has been successfully used at Sandia to arrive at business-driven solutions [2].

In order to focus our interactions with the sites and DOE personnel, we are using a combination of modeling techniques: 1) natural language-based information modeling and 2) business process modeling. The information modeling methodologies help us capture the information required to address DOE's nuclear material management needs, the data processing that occurs at the sites or at DOE, and the information flow between DOE and the sites.

In the natural language information modeling methodology, the initial problem statement is often a narrative. The methodology provides a way to decompose the problem statement into simple sentences and formally model them to unambiguously identify all of the relationships and constraints in a way the user can review them to verify or correct them. The information model consists of a set of facts, examples and constraints. A fact consists of two objects and the role or relationship they have with each other. The model can be represented in either of two ways – verbally or graphically. The verbal, natural language, representation can be read and critiqued by subject matter experts with no training in the formal methodology. The graphical representation shows relationships among entities more clearly and concisely, but does require a brief explanation to be understood [3]. Figure 3 is a graphical representation of a model of an *operation* (e.g., machining) that may be included in a material process (e.g., make part), that uses a certain type of equipment (e.g., lathe), that has some costs and capacity (e.g., two operations/day) associated with it.

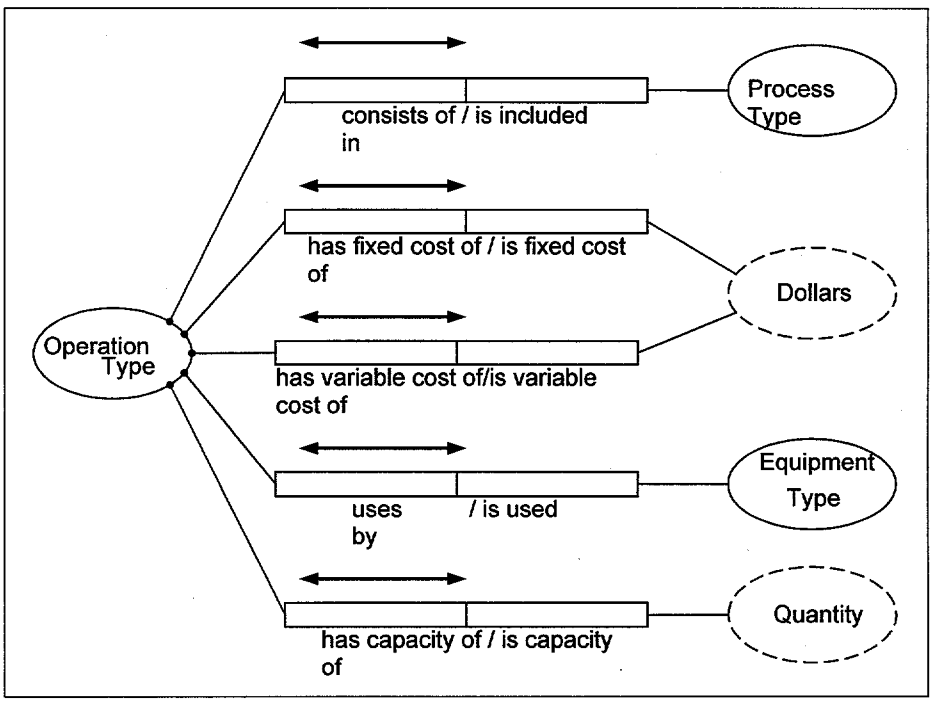

Figure 3. Information Model for a Site Operation

In the business process modeling methodology, the central item is a *process* which takes information/data as an *input* and transforms the inputs into one or more (information/data) *outputs*. The process is enabled by *mechanisms* which are illustrated by arrows coming in from the bottom and controlled by *constraints*, shown as arrows coming from the top. Processes may be broken down into sub-processes using the same approach. This methodology lends itself well to a top-down look at the business processes. The graphical approach can help clarify where a business process can be streamlined. This approach helps capture the infrastructure and information processing details in a way complementary to the natural language information modeling approach. The input and output data flows are sets of facts identified in the information modeling. Figure 4 is a graphical representation of the DOE inventory and forecasting information process.

In parallel with these modeling approaches, we are exploring commercially available technology options for implementation. While we may still consider data warehousing and enterprise-resource planning tools for the long-term solution, we are currently focusing on PC-based modeling/simulation and optimization tools for a proof-of-concept demonstration. The HEU forecasting and planning example described above is essentially a supply-and-demand problem. We are in the process of building up a model with all of the relevant features necessary for simulation and optimization. A modeling/simulation tool will provide an intuitive graphical user interface and the ability to explore *what-if* scenarios. An optimization tool will provide the ability to explore optimal solutions, either in terms of cost or time. We are also exploring communication options including a Java servlet approach and the networking infrastructure provided by COMPASS (Confederation of Models to Perform Assessments in Stockpile Stewardship), a DOE/DP-wide production modeling project.

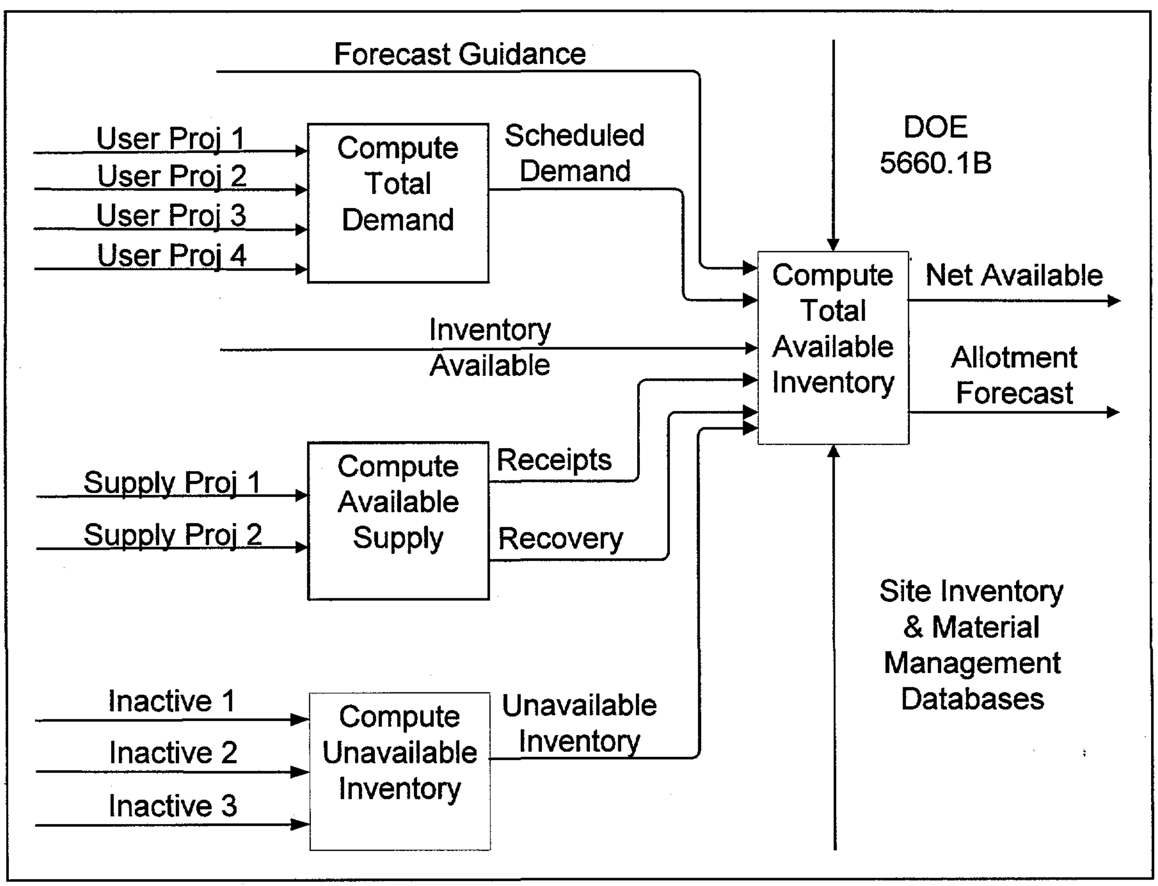

Figure 4. Process Model for HEU Inventory Information Flow

Results

DOE/DP requires better nuclear material management-related assessment, forecasting and planning tools in order to:

- Identify material gaps;
- Identify gaps in processing capabilities;
- Identify container needs;
- Identify storage requirements; and
- Optimize storage volume and costs.

As described above, we are in the process of identifying the major DOE information systems that contain the relevant data. We are using the information modeling approach to define in detail the information that is needed to address planning and forecasting of material usage and where that information resides. Data from current inventory data systems will need to be combined with additional information, including condition/grade, form, material quantity, material commitments, and material processing options (including status, cost, and capacity). The sensitivity of this information is quite high, especially when aggregated in one system. As a result, computer security requirements will be a significant constraint on any software development effort.

A high-level five-year plan for this activity is being developed. During FY00 the project is focusing on the definition of the concept and the development of a more detailed project plan for FY01-FY05. A phased approach will be used to provide capabilities for Defense Programs users as soon as possible.

During Phase I, the Enterprise Operations Analysis and Modeling component will exploit capabilities that are immediately available through commercial products. The Enterprise Data Warehouse will obtain data from existing national nuclear material databases and existing site systems. The Enterprise Network Services will utilize existing network services (e.g., SecureNet) and provide DOE-DP with some basic features to help answer questions and will help to further clarify the system requirements.

During Phase II, the Enterprise Operations Analysis and Modeling component will be expanded to provide core analysis and modeling features that are not directly available through the commercial products. This will establish a foundation of analysis and modeling tools that will become more powerful as the system acquires more data throughout the phases that follow. The core Enterprise System Integrity Analysis features will be developed and the Network Services will be expanded to provide new features required for connecting with and securely transmitting data from all the planned national and site information sources.

During Phase III, new functions developed during Phase II will be integrated with the Phase I system. This will include the new analysis and modeling features, the new integrity analysis capabilities, and the new network services features and connections. It is expected that in parallel with the Enterprise Plan, each site will have a plan to integrate and enhance their capabilities to support their local operations as well as the Enterprise system. This might include: the integration of existing systems to decrease redundancy and consolidate resources; enhancements or new systems to provide additional data and site analysis and modeling capabilities; integration of new systems and old systems; and formal testing, training, and acceptance. In addition, national nuclear material database enhancements are expected to become available. These new systems and data will be incorporated with the Enterprise system during this phase of the project. At the end of Phase III, the DOE/DP will have a system that, in addition to answering questions quickly, will help them understand the implications of decisions, monitor their decisions, and forecast future needs. Phase IV will conclude the effort with formal testing, training, and acceptance of the system.

Conclusion

This paper outlines an ambitious multi-year development project to provide a state-of-the-art Integrated Inventory Information Management System for DOE/DP. This project will focus on understanding DOE's material management requirements and developing a system to support these needs. This project team is aware of other DOE materials management initiatives and will work to assure that the goals of the IIIMS project are consistent and synergistic with all other DOE material management initiatives.

Acknowledgments

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