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ADVANCED NEUTRON SOURCE PROJECT INFORMATION MANAGEMENT

A Model for the Future*

Kathryn King-Jones
John Cleaves
Oak Ridge National Laboratory
P.O. Box 2009
Oak Ridge, Tennessee 37831-8218

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Kathryn King Jones
John Cleaves
Lockheed Martin Energy Systems, Inc.
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Abstract

The Advanced Neutron Source (ANS) is a proposed new research facility that will provide steady-state beams of neutrons for experiments by more than 1000 researchers per year in the fields of materials science and engineering, biology, chemistry, materials analysis, and nuclear science. The facility will also include irradiation capabilities to produce radioisotopes for medical applications, research, industry, and materials testing.

This paper discusses the architecture and data flow used by the project, some quantitative examinations of potential cost savings and return on investment, and software applications used to generate and manage data across IBM-compatible personal computers, Macintosh, and Unix-based workstations. Personnel management aspects addressed include providing paper copy to users only when needed for adequate technical review, using graded approaches to providing support for numerous user-needed software applications, and implementing a phased approach to compliance with computer-aided acquisition and logistic support (CALS) standards that allows sufficient user flexibility for performing technical tasks while providing needed data sharing and integration.

Introduction

The Advanced Neutron Source (ANS) is a new $2.9 billion research facility proposed for construction on the U.S. Department of Energy reservation near Oak Ridge National Laboratory (ORNL). Its 330-MW heavy water reactor will be used to provide steady-state beams of neutrons for experiments by more than 1000 researchers per year in the fields of materials science and engineering, biology, chemistry, and materials analysis. The facility will also provide irradiation capabilities for the production of radioisotopes for medical applications, research, industry, and materials testing (Peretz 1992).

Lockheed Martin Energy Systems, Inc., (LMES) will be responsible for design of research instruments and other experimental systems equipment; for technical oversight of all work throughout project design, construction, and start-up; and for operating the facility. Design integration, facility design, reactor systems design, and construction management will be performed by an industry team with nuclear design and construction experience. The industry team will consist of a prime contractor, an architect/engineer (A/E), a reactor manufacturer (RM), and a construction manager (CM).

Documentation needed to support design, construction, and operation of ANS is expected to be similar to that needed for a nuclear power plant. If current practices are continued, this will result in the generation and management of more than 100 million pages of paper during the 10-year design and construction phase of the project. Storage of this information as paper would require constructing a building, in addition to the labor costs associated with handling paper. Thus, there is a great incentive to handle information electronically.

Over $100 million of control and information computer networks will be used to make ANS the most highly automated and integrated research facility yet constructed. The facility will include an experimental systems computer network to collect and manage experiment data from research instrumentation, business computing systems to manage operations and maintenance activities throughout the life of the facility, and a project information network (PIN) to generate and manage design and construction data.

This paper is primarily concerned with the network that will connect LMES, the industry team, and other project participants so that data can be shared and integrated (see Fig. 1). This network will be a key element in creating the tens of thousands of construction drawings, specifications, instructions, procedures, and other documents needed to support design, construction, and start-up. Further, since the ANS Project performs almost all functions needed for any major engineering/construction project, the techniques and software developed for the network can be easily adapted by other engineering/construction organizations to support major construction projects.

Although the network's numerous technical features will save *tens of millions of dollars (Brake 1990), this paper will deal* primarily with the management aspect of guiding technical personnel into this new electronic environment. This choice of focus is important because the actual cost savings are directly correlated to the success achieved by implementing this culture change.

Network Purpose

The main purposes of the network are to:

1. support efficient production, generation, review, and approval of design and construction data by the project team and
2. automate the turnover of this information to operations and maintenance personnel who will operate the plant.

The purpose of this network is not to replace the human functions of analyzing, calculating, or otherwise manipulating data to produce technical output. The network is to provide ready access to data, software, and other tools needed by users to perform these functions. This distinction is significant because having network functions perform design tasks would lead to significant validation and verification concerns. By restricting the

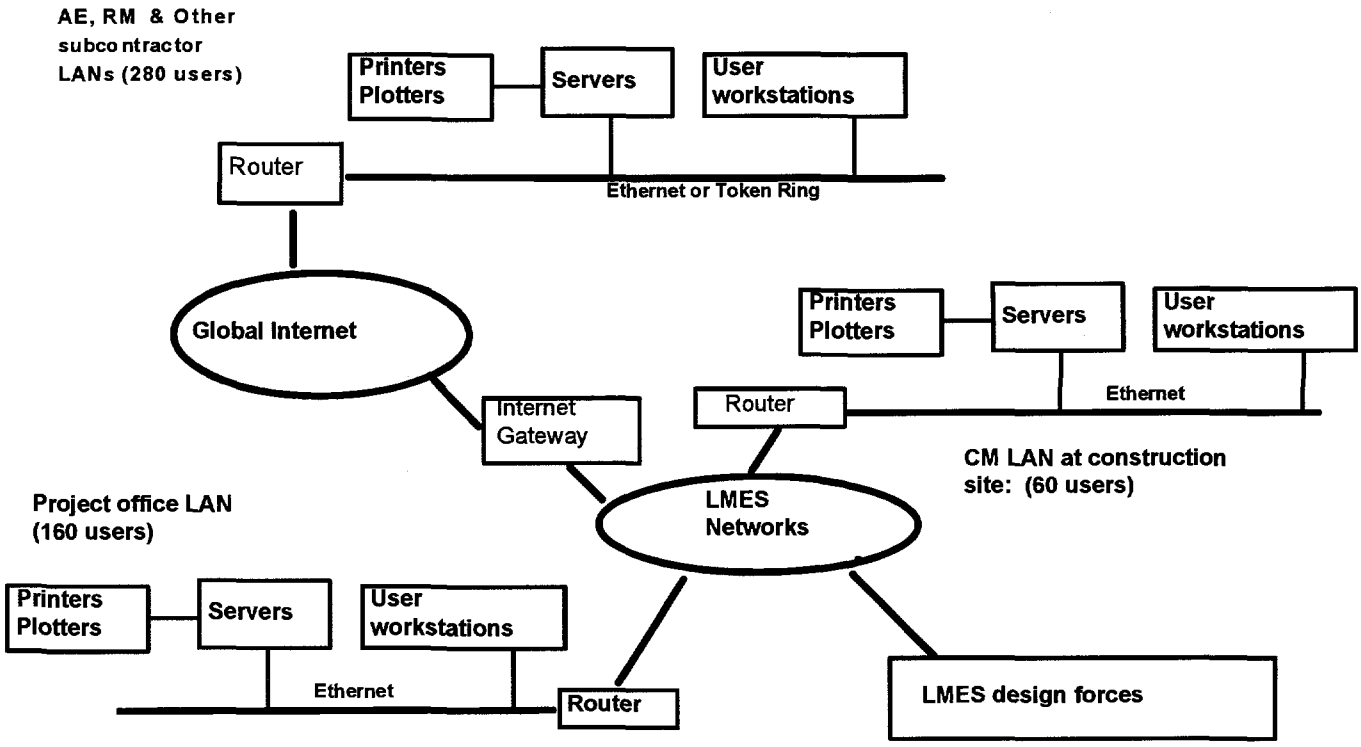

Fig. 1. Advanced Neutron Source Project Information Network. (Note: A/E = architect/engineer, RM = reactor manufacturer, LAN = local area network, LMES = Lockheed Martin Energy Systems, Inc., and CM = construction manager.

network function to providing software and data effectively to users, validation and verification considerations for the system apply essentially to software used for design calculations, analysis, and model and drawing generation as they have in the past.

Research performed for the Electric Power Research Institute shows that for nuclear power plants, approximately 80% of personnel time is spent locating data and 20% performing the task for which the data are needed. Further, 70–80% of this labor cost is recoverable (EPRI 1987). The design and construction management effort for ANS consists almost entirely of information-handling tasks and is expected to cost approximately $500 million over 10 years. As a result, the ANS network represents a potential savings of approximately $300 million by improving the efficiency of locating and managing data. Because all of the technology will not be available and because the users of the technology presented by the network will not all be totally adapted to its use at the start of the project, the full savings potential will probably not be realized.

Recent experience in using three-dimensional computer models and other computer-aided engineering techniques indicate a potential for 15–25% cost savings in engineering, maintenance, and construction tasks that have resulted in savings of tens of millions of dollars. Examples include the design and construction of the Boeing 777 (i.e., the "paperless" airplane), Gilbert/ Commonwealth, Inc., paper mill projects (Warren 1994), and reduced nuclear power plant maintenance costs and outage times.

Based on these recent results, it is reasonable to expect that the ANS cost saving would be on the order of 20% of its potential or approximately $60 million. This is a respectable return on an $8 million investment in the network, especially considering that $3 million of the network cost is for user workstation hardware that is needed irrespective of the network. Thus, a $5 million investment will probably produce a $60 million return.

The ANS Project team will include operations and maintenance personnel and will generate all operations and maintenance procedures, training materials, instructions, manuals, and other materials needed for operations at start-up. These operations and maintenance data will be stored in the facility business computer systems. Thus, at start-up, facility operations and maintenance personnel will use the data that the project team design and construction forces generate. In addition, the facility business computing system applications (although different than those used by the project team) will need to access these data.

Therefore, the network will greatly simplify the traditionally expensive turnover activity of preparing data for operational use by storing the data in electronic forms that are readily usable by operations, maintenance, and facility business computing system applications. Information turnover should be no more complicated than deactivating the network equipment and continuing operation of business system applications with the same set of data (Fig. 2).

Requirements Development and Network Design

The approach to managing the change to the electronic information system, or network, integrated the principles of Total Quality Management (TQM) and computer-integrated manufacturing (CIM) as described in Jacobs and Clemson (1994). This approach resulted in a development method having users involved in a business analysis, a pilot network, the determination of detailed requirements for software applications, and network management.

Development of the network began by determining user requirements by performing a business area analysis (as prescribed

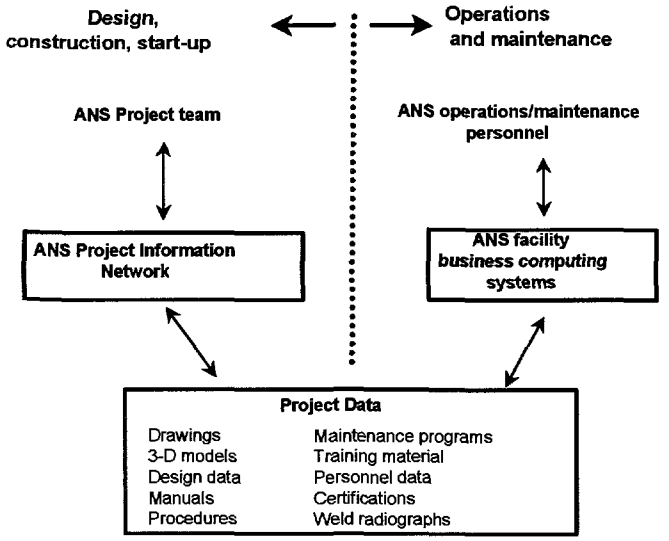

Fig. 2. Information transfer to operations.

by information engineering methodologies) and by installing a pilot local area network (LAN) whereusers could try out services and pilot some of the necessary software. The analysis involved numerous users from all aspects of project design through start-up phases and covered cost estimating, scheduling, configuration management, system engineering, project management, quality assurance, collection of labor and material costs, cost and schedule control reporting, records storage and delivery, and all other business activities performed by the ANS Project team. The business analysis determined the network architecture and identified the business systems and corresponding software that will be needed. The LAN enabled users to pilot some business activities and software functions by using commercially available software and manually manipulating files, documents, and data to demonstrate the automatic actions that future software would provide. This piloting activity confirmed and refined requirements for the operations of software systems.

Graded Approach

The key to integrating human activities effectively into the technology offered by the network is to use a graded approach to the use of paper, standards for work produced, software support, and compliance with CALS standards. This graded approach divides all user-generated data and documentation into**working files** and official project files called **transmitted files**.

Working files are documents and/or data that are in the process of being generated but that have not been officially submitted to the project. These files exist in a combination of electronic and paper form and may reside on user workstations, on network servers, or in user offices. When working files are officially presented to the project for review, comment, approval, or other project activities, they become transmitted files. These files are expected to be mostly in electronic form, and they will reside only on network servers (or, if not in electronic formats, in official project paper file storage systems). Working files become transmitted files via an electronic transmittal function that collects all information pertinent to the document or data being transmitted so that the data can be properly managed. This approach is shown in Fig. 3.

When working files are transmitted to the project as official

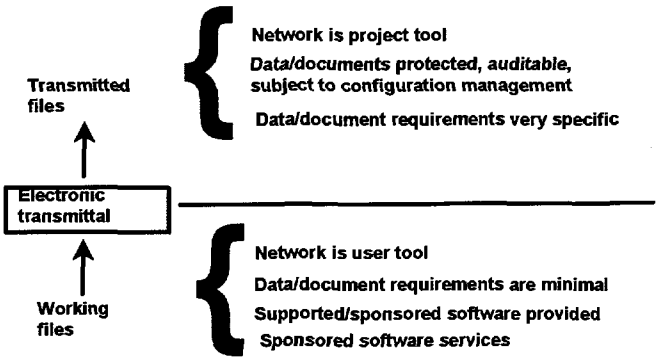

Fig. 3. Graded approach to network use.

data, the way users perform their work, the personnel needing to view and review that work, configuration management functions, the use of the network, and nearly all other functions will change, so the requirements for these transmitted files are different. When users are generating working files, the network functions primarily as a user tool that provides software services and data. When handling transmitted files, the network becomes primarily a project tool that provides appropriate configuration management, data protection, and storage.

The Role of Paper

Eliminating the use of paper in generating, storing, and retrieving information is not reasonable at this time because many technical tasks require paper. Available software applications are not suitable for performing all technical tasks, and many users are comfortable reviewing complex drawings, large documents, and other technical documentation only on paper. However, the network will provide viewing applications for three-dimensional models, drawings, and page-oriented documents and mechanisms for users to generate paper copy easily when needed. In this way, the project will attempt to encourage the transition to the electronic environment and reach an optimum configuration of electronic versus paper usage by enabling users to determine when paper is needed and by providing a mechanism to generate it. This policy is in contrast to the present method of providing paper copies to all users needing to see documents or data regardless of the feasibility of electronic viewing.

In addition to providing storage, tracking, and other management functions for electronic files, the network will track the location, status, and other appropriate attributes of transmitted paper files to facilitate retrieval. Where warranted, paper files will be scanned to make an electronic file that will be managed on the network.

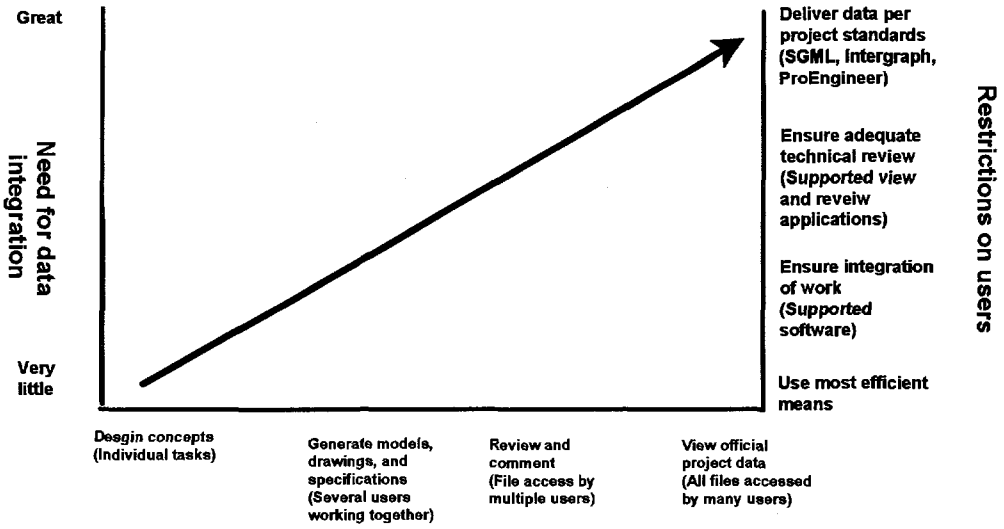

Fig. 4. Graded approach to standardization.

Graded Approach to Work Standards

Working file data are usually generated by a few users on an informal basis. Requirements for how user data are stored or managed focus on providing a reasonable degree of efficiency in users working together while providing sufficient flexibility to ensure that technical tasks can be performed easily and accurately. Of course, users must keep in mind that project requirements for transmitted files must be met when the work is complete. The ability to change or revise data (write privileges) is given to the users needing it.

Transmitted files need to be viewed by many project team members and must have appropriate storage, protection, tracking, and other management provisions. Requirements focus on allowing all users to view and review the data and ensuring that appropriate configuration management activities, data protection and storage, and other project functions can be performed. Users cannot change transmitted files. Generating the next revision of a document or data by changing the latest revision is performed by furnishing the users an electronic copy that they may use as a working file.

This graded approach to requirements is shown in Fig. 4. This figure illustrates the requirements that the users must meet for each project information phase based on the corresponding need for data integration. For example, the data integration need for files that must go through a review and comment cycle is great; therefore, the users must follow fairly stringent standards (i.e., use supported viewing and commenting software).

Graded Approach to Software Support

Users will need a large number of software applications to accomplish their work. The cost of providing a network management team with sufficient personnel and expertise to train users, to provide consulting and troubleshooting, to keep applications running properly, and to perform other functions needed to make all of these applications usable would be prohibitive. On the other hand, restricting the software applications to those that can be supported properly would prevent users from gaining access to the applications they need and from creating improved methods for performing work.

In order to provide needed user software and enable users to create improved methods at a reasonable cost, network software applications will be divided into supported software and sponsored software. For supported software, network managers and software developers on the network management team will perform all tasks needed to ensure that users can use the software effectively. For sponsored software, network managers will install the software, perform software metering and other license maintenance activities, and ensure that the software can be properly activated. All other actions needed to make the software functional will be performed by its sponsor—a user designated for this task.

Generally, supported software will include all custom-developed software; software to provide project functions on transmitted files, operate the network, and provide project management functions; and appropriate applications for computer-aided design (CAD), electronic mail, word processing, spreadsheet, data base management, and other needs common to all users. Sponsored software will include applications that users want to test or investigate, applications for computer-aided engineering (CAE) calculations and analysis, and other applications that vary widely among users and for which technical personnel are needed to provide training and consultation.

Graded Approach to CALS Compliance

CALS is a U.S. Department of Defense strategy for evolution from the current paper-based information environment to an electronic, integrated information environment (DoD 1989). The CALS approach is to use a suite of standard, neutral data formats to generate comprehensive product data bases for weapons systems. Similarly, ANS will use an appropriate suite of standard formats to generate comprehensive data bases for transmitted data. Thus, the objective of the CALS program and of this network is a set of complete, integrated data structures that are accessible by appropriate authorized users. Further, CALS-compliant technologies can be helpful to ANS.

The CALS technologies most applicable to ANS are the requirements for use of the Initial Graphics Exchange Specification (IGES) for vector graphics, Product Data Exchange (PDES) and Standard for the Exchange of Product (STEP) model

data for machine-interpretable product models and numerical-control machine programs, and Standard Generalized Markup Language (SGML) for page-oriented documents. ANS CAD applications will be IGES-compliant for the most part. The use of CALS standards for numerical control machine fabrication of components will be evaluated during the project design phase after more is known about the components to be used and about the capabilities of the industry team participants who will be performing design and fabrication tasks.

A graded approach will be used to apply SGML standards to page-oriented documents where appropriate. The key objective of SGML standards and the software applications that implement them is to provide operators with a quick, easily readable display of procedures, technical manuals, and other documents that are not likely to change. Achieving this objective will greatly facilitate the migration of operators to an all electronic environment. At present, SGML-compliant software applications do not readily support documents needing frequent changes and revisions. However, the key objective of design documents that support construction is to convey fabrication and construction requirements that must be frequently revised and updated throughout design, procurement, fabrication, and construction. ANS will monitor the progress currently being made to make SGML-compliant applications more capable of handling frequent document revisions. Present plans are to use these applications for documents that will be used routinely by operations and maintenance personnel (procedures, manuals, training material, etc.) and for design and construction documentation when the technology matures to a point where migration from existing applications is warranted.

Summary

ANS will likely save tens of millions of dollars over its 10-year design, construction, and start-up by implementing an $8 million network (which is only $5 million more than the necessary hardware investment). The network will empower users to generate paper copy only when needed and to use graded approaches to providing support for numerous software applications, compliance to CALS standards, and data format standards that allow sufficient user flexibility to perform technical tasks while providing needed data sharing and integration. The significant cost saving is a direct result of data sharing—data will be entered into the network once and accessed by different applications throughout the project.

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