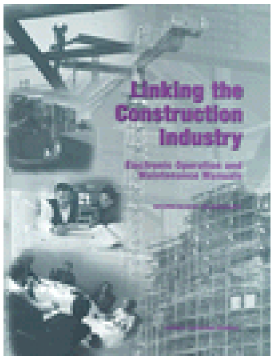

Linking the Construction Industry: Electronic Operation and Maintenance Manuals: Workshop Summary

Board on Infrastructure and the Constructed Environment, National Research Council

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Linking the Construction Industry

Electronic Operation and Maintenance Manuals

WORKSHOP SUMMARY

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Workshop Overview

BACKGROUND

Public agencies, private corporations, nonprofit institutions, and other organizations regularly invest millions of dollars in acquiring buildings and other constructed facilities to support their lines of business. For this investment, the owner receives a complex structure composed of hundreds of separate but interrelated components, including roofs, walls, foundations, electrical, plumbing, heating, air conditioning, ventilation, fire, communication, safety, and architectural systems. These components and systems must all be maintained and repaired to optimize the facility's performance throughout its service life and to provide a safe, healthy, and productive environment for its users and occupants.

Owners and operators of facilities require as-built information from product data sheets, operation and maintenance manuals, design specifications, testing and balancing reports, and other construction submittal documents to manage a facility efficiently and effectively throughout its life cycle. Unlike the purchaser of a car, who receives an owner's manual that provides a maintenance schedule for all systems to optimize the car's performance, a facility owner receives a stack of product data and manuals for each component with little effort made to integrate the information at the system level. Coordination of operation and maintenance schedules to optimize overall facility performance could, however, result in significant cost savings. Consider that, for most facilities, life-cycle operation and maintenance costs will account for 60 to 85 percent of the total life-cycle costs, as opposed to design and construction costs, which will account for only 5 to 10 percent.

Computer experts have developed hundreds of computerized maintenance management systems (CMMS) to help facilities managers organize and control the operation, maintenance, and repair of their building systems and equipment; however, for CMMS to function properly, considerable information about each piece of equipment must be identified in the manufacturers' literature and then must be manually entered into the database. In practice, the cost of collecting and inputting information into a CMMS database can be much higher than the cost of the CMMS itself, and the potential for data entry errors is high. One possible solution would be to have equipment manufacturers supply the required information in digital form so that it could be read directly into an electronic database. Before this can happen, though, data input standards are necessary to overcome the problems inherent in the large variety of CMMS on the market and their many types of data requirements.

In 1993 the Federal Construction Council (now the Federal Facilities Council, or FFC) of the National Research Council[1] held a workshop titled "Developing Data Input Standards for Computerized Maintenance Management Systems",[2] to examine methods for developing a standard electronic format for operations and maintenance manuals. The goals of the workshop were to (1) define the types of standards needed; (2) prepare a plan for developing the standards; and (3) obtain commitments to participate from key parties. Following the 1993 workshop, work on the project continued at the National Institute of Building Sciences (NIBS).[3]

By 1999 a prototype "recommended practice" had been developed, under the auspices of the NIBS and the Naval Facilities Engineering Command (NAVFAC), to facilitate the provision of building information in a format that could be integrated directly with a CMMS database. The prototype practice is based on ISO 8879, Standard Generalized Markup Language (SGML); ISO 12083, Standard Generalized Markup Language Document Type Definition (DTD) (see Appendix C); and NAVFAC Guide Specification 01781 (see Appendix D). Two prototype SGML DTDs have been developed: one for material that an architect-engineer (A&E) organization assembles into a comprehensive facility operation and maintenance manual and one for the product data supplied by manufacturers. The next step is to move into development and application testing prior to full-scale deployment.

In 1999 funding for demonstration or pilot projects became available through grants from the General Services Administration's Reinvention of Government Information Technology Program and from the Tri-Service Computer-Aided Design (CAD) Geographic Information System (GIS) Center, recently renamed the national CAD GIS Technology Center for Facilities, Infrastructure, and Environment. In addition, the NIBS Facility Information Council published the first version of the CAD standard, which is an important component of electronic formatting of information and graphics. In light of these developments, the FFC and the NIBS determined it would be useful to convene a workshop of building industry stakeholders to revisit the issue of electronic operation and maintenance manuals.

OBJECTIVES

The workshop "Linking the Construction Industry: Electronic Operation and Maintenance Manuals" was held at the National Academy of Sciences in Washington, D.C., on October 13, 1999. The key objectives were to (1) demonstrate the prototype practice developed by the NIBS and the NAVFAC; (2) identify the potential costs and benefits of electronic operation and maintenance manuals for the building industry; (3) identify potential barriers to implementation; and (4) develop strategies for implementation, including the identification of pilot projects. The workshop, planned and organized by the FFC and the NIBS, brought together an invited audience of building industry stakeholders, including

[1]The FFC is a cooperative association of federal agencies responsible for the management and operation of more than 400,000 federal buildings and other constructed facilities. The National Research Council is the operating agency of the National Academy of Sciences and the National Academy of Engineering. Additional information is available at http://www4.nationalacademies.org/cets/ffc.nsf.

[2]Proceedings report available at http://books.nap.edu/catalogue/9099.html.

[3]The NIBS was established by the U.S. Congress in 1974 to provide a forum for the construction industry and to identify and facilitate the development of new technologies and processes. The enabling legislation defined 12 public and private sector membership categories. Additional information is available at http://www.nibs.org.

owners and operators from federal agencies and other organizations, building component and system manufacturers, publishers of building product data and maintenance manuals, and CMMS software developers (see Appendix A for a list of participants).

FORMAT

The workshop included presentations and demonstrations of existing and prototype systems for the automobile and building industries. These talks provided context for facilitated work groups (see agenda in Appendix B).

- Mr. Eli Katz, the founder and former Chief Executive Officer of Maintenance Automation Corporation, a producer of CMMS software, addressed the purpose and a vision for the electronic operation and maintenance manual initiative.
- Mr. Eric Jackson from the Atlantic Division of the NAVFAC described the prototype practice DTDs.
- Mr. Ken Poirer from the Tweddle Litho Company of Detroit discussed his experience publishing electronic operation and maintenance manuals for the automotive industry and shared his ideas about how this concept can be applied in the building industry.

Following the presentations, workshop participants formed professionally led work groups designed to identify:

- stakeholder perspectives on the costs and benefits of the prototype practice.
- the audience and market for this technology.
- technological and economic barriers to the implementation of the prototype DTD as a recommended industry practice.
- potential applications for existing buildings.
- methods and strategies for overcoming identified barriers.

Mr. Joel Orr of Joel Orr Consultants began the afternoon session with a presentation on emerging technologies and a vision for the future. His address was followed by facilitated sessions in which the participants were asked to identify potential implementation strategies, pilot projects, and next steps.

A summary of the key points from the morning and afternoon facilitated work groups is followed by summaries of the formal presentations.

SUMMARY OF FACILITATED WORK GROUPS

Benefits of Electronic Operation and Maintenance Manuals

A standardized electronic format could bring significant benefits to building owners and operators. Maintenance management information could be more easily available at diverse locations, rather than through one or two paper copies of manuals, which are often inaccessible. In the nonautomated environment, information is quickly lost, and warranties are not maintained. In the electronic format, information could be entered only once, but used many times. This could eliminate the expensive and frustrating process of entering information repeatedly. Data would have greater longevity, would be more consistent, and more easily updated. An electronic manual could help maximize resources and significantly increase reliability and performance levels, while lowering operating and ownership costs.

An electronic standard could provide for interoperability, making the use of information more flexible. The ultimate reduction of costs could also help offset cuts in funding for maintenance, repair, and operations. Benefits to manufacturers could include cost savings on hard-copy manuals, fewer requests for technical information, increased reliability of equipment, and a capability to meet a growing demand for electronic manuals.

Obstacles to Developing a Standard

A number of obstacles to the successful introduction of electronic operation and maintenance manuals were identified. The effort will require extensive education of project owners and facilities managers to generate the return on investment, or payback, for such projects, since there are few pilot projects in progress that could be used to demonstrate such payback. Although there is pressure today to reduce costs, owners may be reluctant to make up-front expenditures in return for long-term payback. Maintenance staff may resist change for two reasons: (1) they would have to learn new procedures and (2) they may feel a loss of control over their operations because financial executives would have direct access to information about results.

Supporters of this initiative should acknowledge that everyone involved in building a facility may not share the same goals. By involving the operation and maintenance staff from the beginning of a project, their particular concerns, including the associated documentation requirements, can best be accommodated and incorporated into the project. The construction industry is not well positioned for changes in information delivery. Every building equipment and component manufacturer will not have the resources to provide information in SGML, so updating information can be a challenge.

Participants agreed that it will be difficult for everyone in the industry sectors—A&E firms, construction firms, owners, and manufacturers—to agree to one standard. Some level of flexibility in the standard itself and in the way information is input will be needed.

Potential Pilot Projects

It was suggested that any pilot project should cut across the many system types and materials in a building, including all electrical and mechanical systems, to demonstrate how the systems information would come together in a building manual. A pilot project should bring in as many stakeholders as possible and have measurable outcomes, particularly labor savings. A project should also have a broad constituency, such as an office building or health facility, in order for the results to be meaningful to the largest number of people. Also, a project plan should be established for a pilot project, stating what is to be achieved and how. Examples of objectives include lower maintenance costs over a fixed period; reusability of data; labor savings, such as reduced data entry time; and lower cost of performing maintenance tasks.

There was general agreement that pilot projects should be a mix of new construction and retrofit projects. Maintenance costs of new buildings could then be compared to those of older buildings; the comparison should account for the quality of commissioning and staff training.

Return on investment could be defined incrementally. Some participants thought a pilot should be a small project in order to show early success and so that the maintenance cycle could be quantified in terms of its past and future performance. Also, advocates or sponsors should be identified inside various agencies and companies. It is important to find a manufacturer willing to participate and make its data available on the World Wide Web.

Several specific pilot projects were suggested by the work groups as follows:

- Develop a tagging dictionary to tie together SGML and DTDs. A statement of work will first be required. The second step will be to identify existing tagging dictionaries and such initiatives as aecXML (Extensible Markup Language) to determine their implications for this effort. The last step will be to make a recommendation regarding these efforts and proceed to develop an industry standard.
- Apply the prototype practice to a building under construction. The purpose will be to legitimize what has been developed and identify areas that need to be modified. The building owner should be involved in identifying the information needed from an owner's perspective. Possible sites for this pilot project are four Internal Revenue Service facilities scheduled for completion by 2004.
- Apply the prototype practice to an existing building. It would be useful to have a system with an SGML document already available so that the manufacturer could put it on a Web site for operator review and downloading. Data could also be converted into the prototype SGML DTD. Potential sites include Department of Veterans Affairs hospitals, where there is high visibility because of the critical nature of the equipment and the institution. Also mentioned as possible sites were Department of Energy laboratories that have employees experienced in CMMS software.
- Develop the contract language and text for a construction specification that will require the contractor to provide operation and maintenance data in the appropriate electronic format.

Choosing from a variety of projects will allow stakeholders—manufacturers, owners, and A&E firms—to begin efforts in parallel, converge, and then learn from each other as they progress.

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Purpose and a Vision for the Electronic Operation and Maintenance Manual Initiative

Mr. Eli Katz
Consultant

Our goal with this project is to take an initial step toward a set of electronic tools to deliver the lowest possible life-cycle costs for buildings. We are going to do this by applying Standard Generalized Markup Language (SGML) tagging to building text information. We are going to demonstrate the concept that an item of building text information need be manually entered into electronic systems only once during the life cycle of the building. After that, the information can be moved electronically from system to system. (Just for clarification, I am talking about text information that is typed and possibly sketches that are included with the tagging. I am not talking about graphic layout tagging.)

SGML tagging is a worldwide standard for invisible marking of the beginning and end of a piece of electronic text information. It works with and across all computing platforms, databases, and languages. (XML, Extensible Markup Language, is the extension of SGML being created to facilitate Internet and electronic commerce activity.)

For building text information, SGML tags can mark the beginning and end of information elements such as all air handlers ahu-24, the motor of ahu-24, the left bearing in the motor, and so on. The information elements include details such as part numbers, description, dimensions, suppliers, and other purchasing information.

Once information is marked in one electronic system, other electronic systems will be able to find it and use it.

In the future, when a CAD operator selects a particular air handler, the “attributes” will have already been populated using tagging resources and will be available for display, modification, printing, and export. Someday, when the designer chooses a brand and model number of an air handling unit, he will select the “apply” tool in the CAD system. The dimensions and design information will then be imported automatically via an Internet link with the manufacturer because of the tagging resources.

The electronic operation and maintenance manual initiative is a milestone. It is intended to demonstrate and pilot the concept plus produce an immediately useful tool, especially in the federal government environment, by creating an SGML electronic tagging standard for the operation and maintenance manuals of buildings, including the associated equipment manuals. The tool is an SGML, Document

Type Definition (DTD). You have probably heard of Hypertext Markup Language (HTML), the DTD that drives the graphics of the Internet. It works and it is powerful.

The content is based on the Naval Facilities Engineering Command's (NAVFAC) Operations and Maintenance Support Information (OMSI) specification. The tagging is SGML, the worldwide standard.

The information and the electronics work together to produce the benefits. The information content is produced by the building professionals—the engineers, the architects, the building managers, and the owners. The information electronics are produced by the electronic data professionals.

Today, we have the infrastructure of computer hardware, the operating systems, the application software, educated and trained users, community culture, and technical standards to implement this initiative. Also, fortunately or unfortunately, we have a business culture that means this is mandatory. As a consequence of "smart-sizing" and outsourcing, institutional memories are housed in databases, not in people. We no longer have employees with 20, 30, 40 years of experience dedicated to the building. With a continually changing workforce, an organization has to have the automation and electronic systems in place to keep its buildings economically viable and business functional.

Automation is a given. We have to do what we can to reduce the cost and effort of implementing that automation. We are talking about minimizing the costs during the life cycle of a building from conceptualization to disposal.

Bodies of reference information and building information (databases) created during a building's life cycle include feasibility studies, design concepts, design standards, construction codes and standards, plans and specifications, construction submittals, punch lists, commissioning documents, equipment manufacturers' manuals, operations and maintenance support manuals, CMMS data, energy and utilities tabulations, supplies inventory data, furnishings inventory data, specialized smart maintenance and service system data, accounting data, salvage data, and disposal data, among others. This information is used over and over. In the building industry today, the same information is repeatedly being manually gathered and entered many times. This is expensive, time consuming, and frustrating work performed by highly paid, electronically enlightened humans.

The greatest single cost in implementing CMMS, facility management systems, inventory, and other building electronic management systems is establishing the database manually. The greatest single reason for failure to implement or, more often, to underimplement building database systems, is the difficulty in creating the initial database. Today's initiative is a step toward gathering and entering the information only once during the life cycle of the building.

Manufacturers and suppliers produce individual manuals and submit data sheets for each of the myriad equipment and component items of each building. They are usually not readily accessible to building operations and maintenance personnel or for reference when building renovations or additions are being designed. Progressive owners attempt to mitigate this problem by commissioning the expensive and time consuming (but cost effective) preparation of building operation and maintenance manuals.

The specific goal of the DTD initiative is to establish a comprehensive electronic tagging scheme whereby the individual manufacturers' and suppliers' manuals and data sheets will be able to be electronically tagged. These electronic tags will be able to be used to populate needed information in the electronically tagged operation and maintenance manual for a building. The other beneficial uses will follow from this initiative.

Think of where that electronic end-user information could be located. First, there might be paper versions locally or remotely printed. There might be a manual in every mechanic's locker or tucked away in machine rooms. Or the manual might be located on a compact disk (CD) and used or copied completely or partially to the full range of today's electronic systems, from standalone personal computers (PCs), hand-held personal devices, local area network servers, wide area network servers, Internet, and Intranet servers; or they might be incorporated directly into the equipment covered by the manual. In five years, when you buy a new boiler, it might have the microprocessor in it, and the screen and the electronic manual might come in the boiler control panel. Or, the manual might not come with the equipment; it will be accessed on the World Wide Web.

Now, what are we going to do with electronic manuals? First of all, we are going to prepare printed copies and printed extracts for reading. We'll use traditional sequential on-screen viewing, a search engine, and hypertext viewing. When we get to the point where software packages are automatically tagging operational data, it will be a very powerful concept for data reporting and mining. It can be the source of electronic information for manual electronic copying to other electronic systems. Or, we are positioned to have the electronic information automatically copied from one system to another or to have the electronic information automatically directly accessed and used from the electronic manual CD.

The initiative is based on the Navy OMSI standard, which uses the Construction Specifications Institute listing of about 4,000 building elements. As the evolution of the DTD progresses, I envision that experience from the initiative will lead to:

1. Expansion to the finer granularity of the approximately 80,000 building elements of the R.S. Means estimating data base.
2. Provision for tagging to accommodate facility geography such as site, building, floor, room, zone, and functional space.
3. A methodology for ongoing timely expansion of the standing lists of building elements and their components.
4. Provisions for tagging to be applied to elements and facilities not covered by standard tagging listings.

There is a saying, "Build it, and they will come." If the building professionals will define the application requirements and listings of building components, the electronic data processing professionals can build the SGML, XML, HTML, or whatever future technology tools are needed to meet our goal. It is that simple.

The DTD you will see today is the initial model of those tools. The NAVFAC's work, built on the Construction Specifications Institute standard, is the content, the building professional's definition of the data. The content model was combined with the SGML worldwide standard to produce the application DTD. The benefits and the paybacks that are to be achieved are electronic tools for the lowest life-cycle cost. How? Information is manually entered only once. It is conveniently and instantly accessed. By bringing down implementation costs, the specific feasibility threshold levels of setting up automation will be lowered. Documentation costs will drop. Setting up automated inventory systems and supply chain management are major costs that will be significantly decreased.

The initiative will enable a rapid increase of several orders of magnitude of the state of the art of automation of building operation and maintenance functions. This will cause significantly increased reliability and performance levels and dramatically lowered operating and ownership costs. This will happen quickly because of the opportunity for major profit that will become available to the highly aggressive and competitive automation suppliers.

It will also enable us to put more "smart" tools into the hands of mechanics. As a mechanic travels through a facility, there will be smart electronic troubleshooting tools as part of his mobile tool kit. Having tagged data available will increase the speed at which smart systems, on-screen prompts, coupled with sensors, are available. This will result in lower training costs for mechanics and reduced time to make them fully productive in a building. The mechanic will be empowered to access and use the information, resulting in lower costs and enhanced reliability.

3

Experience Publishing Electronic Operation and Maintenance Manuals for the Automotive Industry

Mr. Ken Poirer
Tweddle Litho Company

Today I hope to draw some parallels between the automotive and the construction industries. Some of these will be obvious; others will stretch your powers of imagination.

A key to this effort is keeping the building professionals and the data professionals focused on their respective fields, yet work together. We think the best way for data professionals to help is for the building owners to identify their goals and needs. Data professionals can then develop ways to achieve those goals.

The Tweddle Litho Company does a wide range of publishing-related activities within the automotive industry. We write the copy in Standard Generalized Markup Language (SGML), print the book, and put the same information out on compact disk (CD) or on the company's Internet. We provide foreign language translations and print from as few as five manuals to as many as one million.

Tweddle Litho services the automotive, medical, chemical, and electronics industries. We publish operator and owner guides, service and repair information, training manuals, directories, parts books, price lists, and other publications.

We handle all owner literature for the Ford Motor Company. For Daimler Chrysler, we produce all owner, service, diagnostic, and flat-rate manuals worldwide. At General Motors, we produce owner manuals and other miscellaneous publications. For Nissan, we handle owner, service, and flat-rate manuals. In some cases, as with Nissan, we offer the information as well as produce the literature.

When producing domestic manuals, in some instances, the authoring source (customer) exports SGML to the Tweddle Litho database. In other cases, we have local authoring sources that will supply that information to us via the Internet, T-l lines, or on a disk.

Tweddle Litho converts the data using conversion software. This involves taking the SGML and putting it into an ASCII format that allows other software to compose pages. Once the pages are composed, we send electronic files back to the customer for approval. When we receive approval or edits from the customer, we make the edits, recompose the pages, and send them through a proofing cycle. Once the proofing is done, we send that information to be printed or uploaded to a CD or the customer company's Internet.

Tweddle Litho also produces foreign language manuals, which involves basically the same process. Once we receive the SGML files, we can compare them with a previous file and identify changes. The changes are sent to in-country foreign language translators, the translated changes are integrated into the previous file, and then returned.

The automobile industry developed a set of standards for the electronic interchange of service and diagnostic information in response to the Clean Air Act of 1990 (J2000 standards). I think the T2008 standard for trucks is more applicable to the construction industry. It involves heavy trucks, which typically have more maintenance and are on the road for as long as 20 years. Maintenance is tracked and updates are made when different components are used for replacement or repairs. The parallel with the Operation and Maintenance Support Information (OMSI) system is to create a standard for all the operation maintenance and repair manuals. This ensures uniformity of delivery and consistent data output. Every book should have the same look and feel, so people can share that information from one building to the next. They also want to share that data from one book to another book to optimize the data.

What are some of the similarities between the two industries? The use of standards, uniformity of input format (SGML), the deliverables, the ease of use, trackability, and long-term data usage.

Where do these industries differ? At present, the construction industry is not as suited for a complete change in how information is provided. Not everybody currently has the resources to provide information in SGML. For the automobile industry, it is easier because it has the resources. The only challenge for automotive companies is to find a common format.

For buildings, the intervals at which information is updated might not be as frequent as with vehicles. Also, although the automobile or trucking industries supply technical service bulletins to their representatives in the field to show changes, there may not be a comparable application in the building industry. If building equipment manufacturers are not organized to provide updated information on building components, updating the information provides a challenge.

The publisher's challenge is to take every conceivable format in which the construction industry is going to provide that information (Pagemaker, SGML, Word, WordPerfect, Portable Document Format (PDF), hard copy, handwritten, etc.) and narrow it down into Document Type Definition (DTD)-compliant SGML for the creation of the manuals and CD output.

How do we bridge the gap? How do we create a solution? You have to think outside the box. The easiest way to create the solution, but which may not be cost effective, would be to give everybody an SGML monitor to provide that information just the right way from the data professional's perspective. We need to make it simple for everyone. We need to allow for a variety of formats, but at the same time reduce the possibilities. We can create data templates for non-SGML data using the lowest common data formats.

Another possibility is to give direct Internet access to allow anyone to enter data online, using a template. Once the information is typed into a template, it is invisibly tagged, and SGML makes it applicable to that DTD. Some of the recommended solutions are to develop a free or inexpensive forms-based authoring tool. That might be the template for the different Word or Pagemaker files. Another solution is to outline a limited set of alternative data formats, provide authoring templates, and develop conversion services.

Updates to the data can be made in SGML by the vendor. The vendor can create a database of manufactured products and can pull from that database any duplicate information. If one submits a suggestion, if they are using a common format from one building to the other, there is no need to recreate that data. Once data are converted, they can be used over and over again.

Here is a work flow vision: Receive the data in multiple formats, convert them to SGML as necessary, validate the SGML files against the DTD to make sure that the file is usable once it is converted, run the SGML files through conversion scripts and through a composition engine to compose pages in final format, send the proofs out, and upon approval, print manuals and output CDs.

One of the next steps is for the printing and the building industries to determine the total number of formats in which the information can be provided. What is the lowest subset of information that needs to be provided that can be turned into SGML?

Another step is to determine the viability of creating a free or inexpensive authoring tool. The creation of templates and conversion scripts for SGML data conversion is needed. To determine how this will work, the publishers could receive sample or test files in order to create sample operation manuals and do a pilot test.

I'll leave you with the following questions:

- How can SGML data be used beyond the printed manual and the CD?
- Can it be interchangeable with a CMMS system?
- Can the data be downloaded from the operation manuals directly into a CMMS system?
- How will updates be handled?
- What systems will be in place to maintain the integrity of the data and what are some of the future applications of those data?

Question and Answer Session

PARTICIPANT: Where are the automotive industry and your company going with respect to XML?

MR. TAKACH, Tweddle Litho Company: We have stayed with SGML because it is the standard the automotive industry has chosen. XML is a subset of SGML, and we can convert the SGML to XML later if needed.

PARTICIPANT: One concern that I have is that many craftspersons and technicians are so accustomed to paper documents, stick files, and drawings that there will have to be cultural change. We must create the technology that will enable all of this to happen, but that will not occur if we do not at the same time work the cultural change that is required at a personnel level. A second concern is that we need to take the data in our CMMS and generate valuable information for the facility managers to make informed decisions on how to use their resources.

MR. KATZ: Twenty years ago the collective bargaining units of the various craft unions would refuse to work with or would demand special compensation to work with keyboards and screens. That has changed. It started shifting about 10 years ago when, in the negotiating sessions, the unions demanded to be the ones to use the electronic tools, because they knew if they didn't their members eventually would have no jobs. As far as management goes, managers also have to be electronically enlightened, or they are not going to have their jobs anymore. That is where the culture is today.

PARTICIPANT: I agree; however, is it not equally important to develop capabilities to convert these data to information that a facility manager can use?

MR. KATZ: The conversion of the data is what this is all about, and as this grows, there will be a defined cost and a defined flow, just as we are living with scanning paper documents into CAD. What does it cost per square foot to scan paper documents into CAD? A dollar or a dollar and a half a foot? Sometimes the cost of scanning data into CAD exceeds the cost of the building of 50 years ago. We are going to be doing two things. We are going to be funding and converting existing data when the dollars drive it, tagging the existing data, and marking the existing databases. More important, we will put a requirement on the software systems that are creating the databases. The CMMS will tag the work order data and the inventory transactions. By running the CMMS system, you are automatically tagging the operation information. Then the standard management tools, data reporting tools, will work with all brands.

MR. TAKACH: In the automobile industry we had the same problem 10 or 15 years ago. We addressed it by continuing to provide paper manuals. We slowly moved the mechanic from a paper product to an electronic product by just not making the paper available anymore. Now, for example, Nissan is going to go to a complete electronic manual by model year 2001.

The mechanics have reacted to this by recognizing they can print off a page from the electronic manual if so desired and take it over to the car and work with it. Most of them have adapted and said, "I will use my computer because the information is right here on the screen, and I can just keep screening down or tabbing down until I get to what I want." It's a matter of education and working with people long enough to make sure that they feel comfortable working with the electronic media.

PARTICIPANT: My observation is, "Do not underestimate the importance of training." So as you are bringing in the new technology, be generous with the training of the staff that you want to use it.

PARTICIPANT: Can the problem of getting the information into CMMS databases be solved with SGML? What are the manufacturers doing? It seems to me that they should be leapfrogging. Instead of just going back to their old manuals and tagging everything, they should be thinking about how to develop tools to put the data into an electronic form now, as they develop the products. For example, pick a couple of systems and make sure that the available data automatically goes into the computer systems to monitor or maintain facilities. Are you covering that issue in the work done to date? Do you have the manufacturers involved? Are there some manufacturers way out there leading the pack?

MR. BRODT: We have some of the manufacturers here today that we have been working with. Principally, we have worked with Johnson Controls, Siemens, and Trane.

MR. FORD: Johnson Controls is represented here because we believe this is the direction in which the industry is going. Right now, there are a lot of standards coming together in an ad hoc manner. Various manufacturers are trying different formats. We would like to see the industry follow common standards.

PARTICIPANT: I wonder if you could comment on the building automation portion of the industry and the whole idea of interoperability. Do you see the standard extended that far? Do you see a single, seamless database at that point?

MR. FORD: Yes, we see all of that coming together into a common system.

MR. KATZ: When used on data, SGML can in a very smart, powerful way identify a specific, as fine a granule of data as is needed. We are marking, we are tagging, we are flagging data, and it goes across all brands of software, and it even works on mainframes. That is the power to think about. It is the data that are tagged, and we as managers, buyers of the software, have to put the requirement on the software producers to put in the tags. The people who own the data force the suppliers to open it up, so you can go actually deal with another vendor.

MR. RICE: I came here today because I actually am designing and building the kinds of systems that you are talking about. The question is, "What real use is an SGML document? If I give you an SGML document, what can you do with it?" The answer to that, by itself, is not very useful at all. SGML represents kinetic energy. That means I can turn it into a form that can be processed by a CMMS system or some sort of automated maintenance browser system.

The key is that the information is only as smart as I make it. It is only as smart as it is tagged. Just creating a simple SGML document will not allow me to take that information and plug it into a CMMS system and have it do something useful. If it were that simple, then we could all just take HTML pages off the Internet.

SGML is more difficult than some other ways to create information. The payback is that you can do more things with your information, and you can put it into more forms that have more uses.

Whatever you discuss in this workshop and whatever you incorporate into the DTD that you eventually produce, the utility that you get out of your information will be directly related to the level of intelligence built in. Unfortunately, the ease with which the information is produced is proportional to how intelligent it needs be.

4

Prototype Practice for the Building Industry: Operation and Maintenance Support Information

Mr. Eric Jackson
Industrial Engineer
Atlantic Division
Naval Facilities Engineering Command

The National Research Council report *Stewardship of Federal Facilities: A Proactive Strategy for Managing the Nation's Public Assets* notes that although construction cost is a substantial expense it is only the beginning of expenditures for a facility. Operation and maintenance account for 60 to 85 percent of life-cycle costs. Often, we are just focusing on the design and construction costs, but operation and maintenance are actually a much larger expenditure over a 30-year period.

Typically, buildings are designed to last at least 30 years. With proper maintenance and management, they can last from 40 to 100 years or more. The operation and maintenance cost of a building will inevitably increase over time because of age, wear and tear, and change of use. With maintenance and care, the service life of the facility can be extended beyond the initial estimate. However, if you do not deliver maintenance and repair at the appropriate time, you will actually irreversibly limit the service life of a facility. It is like putting oil in your car. If you do it on a regular basis, you will extend the life of that car. If you fail to do it, at some point the engine will fail and you will have to replace the engine or the car. The same can be said for facilities. If we maintain the facility and the systems in it, it will last longer than it was designed to. You will not have to worry about building a new facility.

Our admiral put it this way: "You can buy your way out of most design mistakes, but you will never be able to pay for any operation and maintenance mistakes." Make sure things last for the design life.

In the past, when facilities were constructed, the construction contractors would submit bits of information about everything from doorknobs to major systems. When construction was finished, all of this information was put in boxes and given to the owners or whoever was taking care of the facilities.

Because the information was not organized, it was lost very quickly. Warranties were not maintained and were lost. This would affect the owner's business operations, because systems would go down and the right resources weren't available to fix them.

For the Navy, the NAVFAC would do a great job on building design and engineering. The construction contractor, engineering field division, and the facility user would all do a great job in the acquisition process. When it came to actually turning that facility over to the user, often that user was left to maintain that facility. The user could not obtain help or the support that was needed from the acquisition team. Once the user took over that facility, he lost all support.

In 1988 a public works officer at the Naval Weapons Station in Yorktown, Virginia, refused receipt of a mine warfare building because the officer did not understand what was in that building. The officer did not know how to maintain the facility systems. So, ownership of the facility was refused.

Our organization decided not to let this happen again. Any time we turn over a facility, we are going to make sure that we have the documentation to support it. When an owner takes possession of a facility, the owner has the tools needed to operate it.

The obvious product is information, data that help the facility user and owner to effectively operate, maintain, and repair the facility as soon as they occupy it.

The concept is based on a 1981 article from the Construction Specifications Institute (CSI), "Preparation of an Operations and Maintenance Manual." It addressed the preparation of an Operations and Maintenance Support Information (OMSI) manual. This article stated that the manual should be completed by the designer, not the construction contractor. In addition, the manual should be based on as-built product data.

NAVFAC commissioned an architect-engineering (A&E) firm to review more than 100 contract technical specification sections to identify the type of information needed for equipment for each of those sections (see Figure 1.) Five different data packages were defined. One would be a very simple architectural, something that does not have any moving parts. Four would be the most complex system that requires an operator, has a sequence of operation, startup, and shutdown. Five is the special case of electrical equipment or other equipment for which the wiring diagrams or diagrammatic plans are needed.

NAVFAC guide specification 01781 identifies the data package that is to be provided with a piece of equipment (see Appendix D). It is clear to the construction contractors what information they need to provide with that piece of equipment when they install it.

This is the heart of the OMSI. Without this, it would be difficult to get the construction contractor to provide the information to the A&E firm in order to put together an OMSI. There is no question as to what information the construction contractor is to provide.

The CSI specification technical sections for the different pieces of equipment will identify data packages 2 through 16. The data package points back to the NAVFAC guide spec 01781 that specifically identifies data packages 1 through 5.

All of this information is pulled together into an OMSI manual.

The manual is organized into three parts. Part 1, facility information, includes the facility and system description, design concepts, basis of design, basic data for facility support contracts and performance work statements, site and floor plan information, utility cutoffs, equipment inventory, supply inventory requirements, extended warranty information, training requirements, and a skills matrix. The public works officer can open the manual and actually find out what is going on at that facility very quickly. If we need to support this facility with a service contract or if we do not have the in-house resources to maintain the facility, we can contract it out. We also have the information in this manual to find out how many square feet of tile and carpet there are, as well as how many windows need to be cleaned without having to send someone out to inspect the facility. Any special training requirements for mechanics to maintain the facility are identified.

Part 2 of the OMSI manual contains primary systems information. The A&E firm develops operation, maintenance, and repair procedures for a given system from start to finish. Operation includes system descriptions, system flow diagrams, startup and shutdown procedures, and operating instructions. A mechanic can read this section and understand how this system works and how each component

NAVFAC Guide Spec Section 01781

Data Package Definition

1 *Architectural items, simple but specific maintenance & replacement (acoustical ceiling, floor tile or carpeting system).*

2 *Less Simple, an item having a motor and some sequence of operation (refrigerated drinking fountain).*

3 *Complex equipment, having a specific troubleshooting sequence, but does not require an operator (HVAC temperature controls).*

4 *Extremely complex, extensive sequence of operation, complex troubleshooting sequence, and requiring an operator (boilers, diesel generator).*

5 *Electrical equipment, components or systems which wiring and control diagrams are needed for operation.*

1	2	3	4	5	Data Package Content
●	●	●	●	●	*Safety precautions*
			●	●	*Operator pre-start*
			●	●	*Startup, shutdown, and post-shutdown procedures*
	●	●	●	●	*Normal operations*
		●	●		*Emergency operations*
			●		*Operator service requirements*
	●	●	●	●	*Environmental conditions*
	●	●	●		*Lubrication data*
	●	●	●	●	*Preventive maintenance plan and schedule*
		●	●	●	*Troubleshooting guides and diagnostic techniques*
		●	●	●	*Wiring diagrams and control diagrams*
●	●	●	●	●	*Maintenance and repair procedures*
	●	●	●		*Removal and replacement instructions*
	●	●	●	●	*Spare parts and supply list*
			●		*Corrective maintenance man-hours*
	●	●	●		*Parts identification*
●	●	●	●	●	*Warranty information*
			●		*Personnel training requirements*
		●	●	●	*Testing equipment and special tool information*
●	●	●	●	●	*Contractor information*

Figure 1. OMSI Data Packages

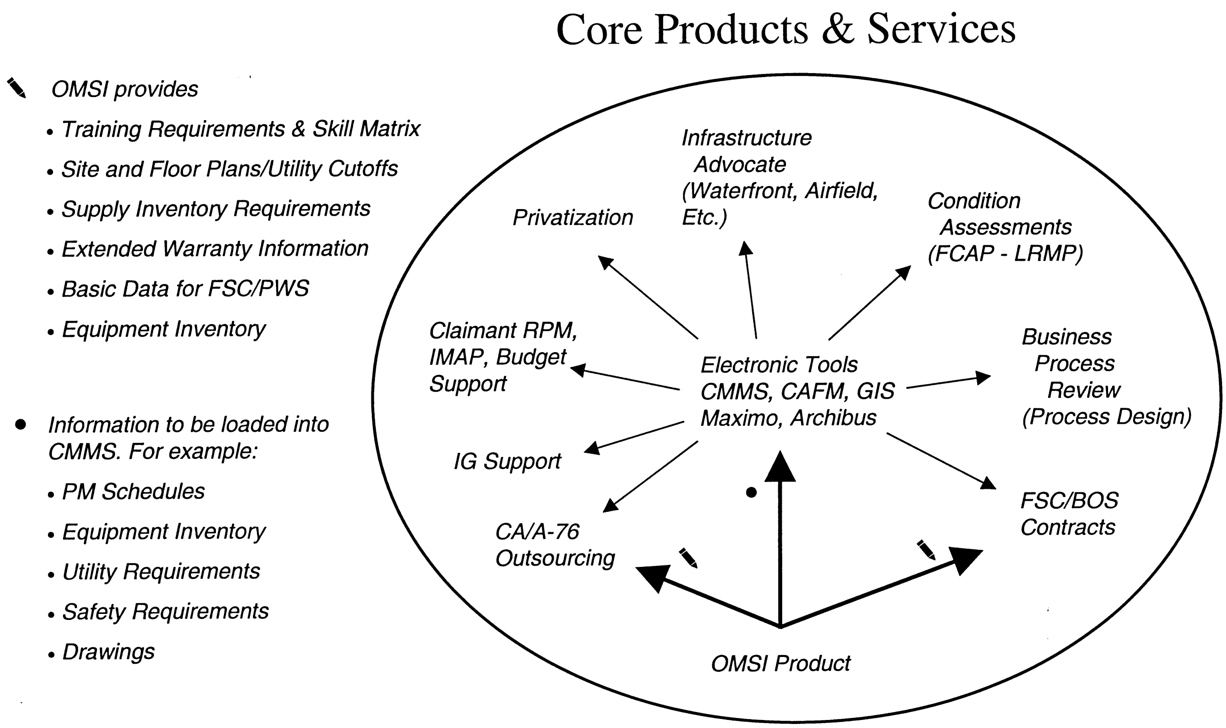

Figure 2. OMSI Benefits

works to support the system. Maintenance includes lubrication schedules and preventive maintenance plans, schedules, and procedures. Repairs include troubleshooting guides and diagnostic techniques as well as repair procedures.

Part 3 of the OMSI manual includes product data. It is a record of material and equipment organized by the CSI master format.

Typically, we have been providing the OMSI manual in hard copy, although in some special cases an electronic format has been used. Our goal is to move the OMSI manual into electronic format completely to enhance its availability and use. Often, when we produce an OMSI manual, we provide two copies. One copy goes to the customer, one goes into the facility, or to the service provider or public works. Generally, those would be under lock and key. If you want access to the manual, you would have to get the person who owns it to let you into the room. In contrast, if it is in an electronic format, it can be put on a local area network and then could be accessed by shop personnel.

Initially, we received a wide range of formats from the A&E firms. We conducted research to identify the best solution in terms of cost and labor. We decided on Adobe's Portable Document Format (PDF). It is an industry standard. In terms of costs, it is relatively inexpensive, around $300. It does not take a great deal of labor to implement.

The cost of OMSI manuals varies with facility cost and system complexity. For example, at the $5.5 million training facility at Oceana, the OMSI cost was 1.1 percent of the estimated cost of construc-

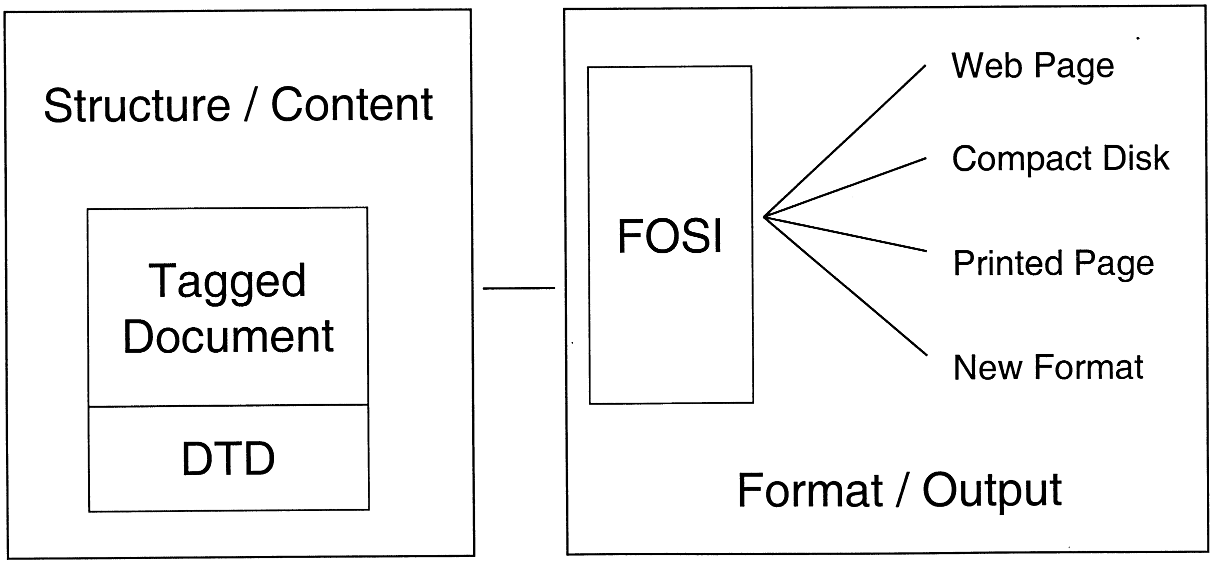

Figure 3 SGML Tagging

tion, or about $61,000. For a health care facility that cost $23.3 million, the OMSI cost was 1.7 percent, or $394,000. The difference is attributable to the complexity of the facility. A health care unit may have anywhere from 10 to 20 systems, whereas an administrative facility may have only 3 or 4. Generally, when we have a concept of design, we try to identify the OMSI cost up front so that part of the budget might be set aside.

OMSI accounts for only a small percentage of life-cycle cost. It is a good investment to help leverage greater expenditures on the facility. It also helps address issues such as commissioning, support contracts, and operating permits.

OMSI has many benefits. One document describes the original intent of the design so that subsequent modifications can remain consistent. OMSI provides an orderly compilation of all as-built product data. Repair responses can be completed more efficiently. It is possible to prepare more detailed and faster facility support contracts. It provides data for CMMS systems. OMSI reduces downtime, which results in improved mission readiness and satisfied customers.

OMSI also benefits the organization because it helps us provide better products for our other areas of business (see Figure 2). Finally, OMSI reduces operation and maintenance costs and saves money. What is next? Electronic delivery of operation and maintenance information directly from the manufacturer. The OMSI manual could be assembled dynamically. An intelligent system could identify itself to a local area network, connect to a manufacturer, and download the product information. It would be self-maintained. Smart facilities and smart systems would be self-diagnostic. It sounds very futuristic, but there are systems like this out there today.

How do we get there? Traditionally, when we think of documents, we think of something that is hard bound. We turn the pages, we mark it up, we tear out the pages. Documents consist of three components: structure, content, and style.

However, if we define a document as a medium for disseminating information, we then can also say that any time information is being disseminated it represents some sort of documentation. The radio is a form of documentation. The television is a form of documentation, as well as the telephone, the dashboard of our automobiles or the cockpit of an aircraft. Like a fluid, as information flows into various shapes (mediums) it takes on the characteristics of that shape or medium. So as we make information intelligent we can customize that information into whatever format we desire.

SGML separates format from content and deals with the relationship between them. Documents can be divided into small elements. Each document type requires a specific Document Type Definition (DTD). An SGML document consists of a tagged document and its DTD. With those two components, a piece of software would know how to process this document, whether it is going to a printed medium or being received by a CMMS system (see Figure 3).

Using SGML has a number of advantages. The data are intelligent. The application and the system are independent. There is portability across various systems and applications. It provides flexibility beyond the traditional publishing of hard copies. The data have longevity: data do not need to be converted when new applications or technologies become available; conversely, SGML is reusable when existing applications or systems become obsolete. Documents can be assembled on the fly and can be sent out into various media without reentry or reformatting.

5

Emerging Technologies and a Vision for the Future

Dr. Joel Orr
Orr Associates International
Bentley Engineering Laureate

There is a lot of brainpower concentrated here, an incredible source of powerful ideas. What is more, the precipitating granule around which we are collected here is some actual work that is being done.

For some of us, the relative improvement of printing on a shiny silver disk instead of on paper seems to be an enormous step. But, in point of fact, it is one very small step for mankind. We need to think beyond this. The leading business speakers say that we can no longer afford to go on fixing the mistakes of the past. We instead have to embrace the innovations of the future. Jeff Besos did not set out to create a somewhat better bookstore with Amazon.com. He made something completely different. I do not even know how you fit eBay into that metaphor. We are doing new things now. I like physical and electronic metaphors, but there is an absence of friction in the commerce world that is brought about by the World Wide Web specifically—the Internet alone was not sufficient. We needed the additional overlay, the World Wide Web, to make the Internet accessible to the world at large.

The taking away of friction has created new things that we could not think about before. Dell Computer, when I last checked, was selling $30 million worth of computers every day on its Web site. That is 365 days a year. That makes it an $11 billion company as of September 1999. The big deal was that they violated a fundamental tenet of business, which is that, if you want to grow beyond a certain size, beyond a certain rate, you must seek outside investment. Michael Dell does not do that. All he asks for is your credit card. When you order your computer, he gets the money from the credit card within minutes of your putting the number in. He does not even have the parts for your computer yet. Then he gets those parts, and he gets them on a 30-day basis. He has your money for 30 days. If he wants to grow more, all he needs is more sales.

Now, unless you are used to thinking in business terms, you do not realize what a revolution this is. This is very, very different from a manufacturer who has to find some money, build a plant, and then maybe start taking orders. So, we are experiencing the commercial world as it affects how we do business and government.

Alfred North Whitehead, a mathematician and a philosopher, said that "civilization advances by extending the number of important operations which we can perform without thinking about them." The fact is, George Miller said it in a famous paper in 1955, "We can only juggle a few things in our mind at one time." Civilization advances by allowing us to get rid of these things or to put them where we do not care how they work. We just move forward.

Marshall McLuhan put it very nicely. He said that "any medium has the power to restructure our minds in a unique way by imposing its own mode of thought."

We have evidence of this from a woman named Jane Healey, who was a kindergarten teacher for 20 years. She was upset because every year the kids coming into class seemed to be less and less able to handle the standard kindergarten curriculum, which she had taught identically for 20 years. She took a sabbatical and wrote a book, *Endangered Minds.* She studied issues regarding brain plasticity: what happens in a child's mind at different ages. The fact is that the more stimulation the child gets at a very young age, the more real estate in the brain gets devoted to input as opposed to output. In her book, she showed a parallel between her experiences with kindergarten-age children and that of other people and the length of an average tape on television. In the television of the 1950s, the TV camera would stay on a scene for 15, 20, or 30 seconds at a time. Today on Sesame Street 2 seconds is a long time. Absorbing this continuous stream of stimulus takes up more real estate, and children's brains, being malleable, being literally plastic, devoted more and more space to input, leaving less for expression, less for output.

Thus, the medium has the power to restructure our minds.

Now, the medium we have been working with in the world of construction is the medieval medium. Any construction manager from 1652 could pop up today and recognize the elements in a construction site without too much difficulty. Structurally, not a great deal has changed. Yes, we have different materials as well as telephone, fax, and computers. That is about it. The medium is changing. The medium that is changing is the electronic medium at large, the ability to communicate quickly. Why? Because it is eliminating float. Information float is the source of power in any organization.

You know what financial float is. You know your Aunt Tilly sends you a birthday check from out of state, and you deposit it in your bank, and the teller says, "I'm sorry, sir, you are going to have to wait 5 to 10 days before you can draw on these funds in your account." Of course, the Federal Reserve delivers those funds that night to the bank, and the bank gets to use them for a few days. That is float on their end. Meanwhile, you write a check you know is not covered to someone, but you also know that your paycheck is going to be deposited in 2 days, and the other fellow uses a different bank. It will take a couple of days to get there. You are using float to your benefit.

The same thing happens with information. The drawings, the models, and the information come to you, and you are supposed to process it before you pass it on. The longer you hold it, the longer your queue, the more important you are to the organization, the higher your prestige rises. Now, someone comes along and says, "Let's implement work flow." This dynamic flow chart will show everybody exactly how the information moves through the organization. Are you going to like that? No. Everybody is going to know not only what time you came to work but how many things are in your queue and how long you took to process them. Do you want people to know that? If you are in middle management, probably not, because of your perception of your control. So, a lot of the resistance to all of this comes from that quarter.

I can take that further. Let me go back, since I started on the Federal Reserve, to Alan Greenspan, who said that information technology has "begun to alter fundamentally the manner in which we do business and create economic value."

In order to improve productivity, we have to think over the continuum of the entire life cycle as well as the continuum of the entire enterprise. The enterprise here encompasses the owner, the product deliverer, the product manufacturer, the architect, the engineers, and so on, everyone who is involved, as well as those who are involved in maintaining this building.

EEM stands for enterprise engineering modeling. Whenever we create a model, it becomes a place where we can gain experience in an environment of attenuated consequences—in a place where you can crash and burn and rise up to crash and burn again. Models give us that opportunity, but models exist within the context not just of design but within the context of engineering at large. In other words, this making, designing, and maintaining of things fits within the context of the overall enterprise.

We need to think of these things as a unit. It is not about having fewer mouse clicks or drawing lines and circles faster or even producing more drawings or fewer drawings, but rather of having an environment, because engineering is a nondeterministic activity. In other words, we do not have formulas into which we plug the givens of the situation and out pops an optimum design and optimum building.

Everything is trial and error. In fact, we do not even have convergent trial and error processes. We have no guarantee that, given more time, we will come up with a better design. What we want is a place in which we can make our choices and see their effects inexpensively.

All of this is happening within the context of a large number of trends, as follows:

- Centralized to decentralized
- Expensive to cheap
- Dedicated to casual
- Closed to open
- Isolated to integrated
- Dumb to smart
- Drawings to models to knowledge
- Procedures to objects to components
- Mediated to immediate
- Local to global
- Seller's market to buyer's market

All of this smart sizing, right sizing, RIF-ing, whatever you want to call it, means a reduction in the number of people to do things, which means each of us wears more hats than we used to.

Therefore, we need systems that support us in that environment, where we do not have to take a 6-week course and then take another course if we leave the system alone for a month. We have to have systems that we can learn to use quickly. Nobody holds a monopoly on any of the system formats. Therefore, we need formats that are open.

One of the big benefits of the Standard Generalized Markup Language (SGML) is that it is machine readable. It is also human readable. We need something machine readable to enable us to exchange information among heterogeneous systems and do the kinds of commercial transactions that have to be made. So, openness is important.

In the programming world, we are talking about a transition from procedures to objects to components. Objects are not of interest to architects, components are. We are moving from systems that are mediated to those that are immediate.

The word "immediate" has two wonderful connotations in English. It means here and now, spatial and temporal connotations. That is what we are moving to, here and now, and of course, local to global, and happily from a seller's market to a buyer's market. In fact, in the design world, we are seeing some major transitions. We are moving from the concrete, which is the thing itself, to a physical model that is less concrete, more abstract, to paper, which does not have to be paper—electronic paper, which seems like but is not a big transition. That is like the transition from paper to CD. That is not a big transition. That is not from horse-drawn cart to automobile. That is from horse-drawn cart to horseless carriage, something that is characterized by the absence of one of its former features, not by the new features that it offers. Information technology is a necessary step in the evolution.

Meanwhile, we are moving along another scale from the real to the virtual. It is from the real to the almost real. Physical models have physical attributes. Virtual models have only those attributes that you consciously give them. You might say that virtual reality is, in a sense, responsible reality. It only has the things you put in. If you want gravity, you put it there. If you want gravity to be 9.8 meters per second or 32 feet, however you want to define it, that is your business.

A recent study shows that the major concerns of people in construction are electronic construction documents and the firm Web site (see Figure 4, emerging trends): in other words, the advertising brochure on the Web. Construction management, design-build projects, smart growth, value engineering, virtual reality tours. Project Web sites are important to only 20 percent of the population and sustainable building green design is even lower than that. Facilities management is lowest on the list of real concerns of the construction companies.

Paul Strassman made himself forever the enemy of other chief information officers (CIO) when he was CIO of Xerox. He wrote a book, *The Squandered Computer,* in which he said there is no correlation between computer spending and profitability or productivity. There is a shocker for you and not something the CIO wants to hear when walking into that budget meeting. In fact, Strassman says there are not even any best practices. However, most CIOs miss the good news in the message, which is that only alignment of business and technology goals can help.

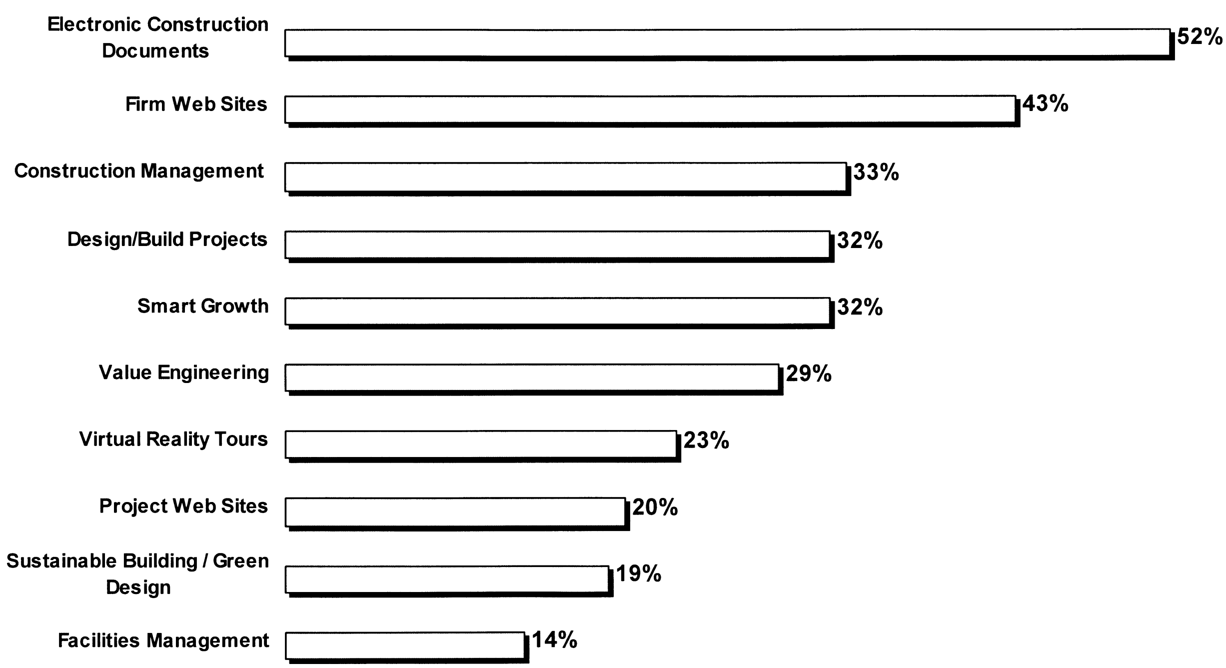

Figure 4 Emerging Trends

In other words, in the past, the CIO charted a course for technology. It had nothing to do with where the business was going. Strassman is saying that the successful businesses are those that are characterized by an alignment of business and technology goals. This certainly goes for government as well as for business.

I want to share with you 10 points by which to measure the value of what your organization is putting into technology.

First, whatever it is, make sure that it preserves the value of your current data.

Second, the system must speak your language. In other words, you cannot bring in a system that totally replaces what you do and expect it to just keep up operations as usual.

Third, it has to reduce and streamline data management. I cannot tell you the number of times that I have seen situations in which it was simple on paper but with computers it takes six more people and is five times slower.

Fourth, you have to empower as many employees as possible. You cannot succeed by creating additional bottlenecks.

Fifth, you have to allow for training. One commercial enterprise gentleman said to me, “I am afraid if I train my people in additional skills, they will leave.” I said, “So, let me get this right. You want to not train them and have them stay?”

Sixth, find permanence through incremental improvement. If you stop the bicycle, it falls over. If you keep rolling, the gyroscopic effect will keep you stable. That is the only stability you are going to find in dealing with technology.

Seven, recognize that the technology is a bridge, not a ferry.

Eight, all of this is going to happen in a world of two-way mobile access (i.e., wireless technology).

Nine is plug and play.

Finally, establish relationships with vendors, not mere transactions. This is not something you can go out and buy. This is something where you want somebody else to worry about the technical details.

In short, you have to demand permanent value from your assets. It will not happen automatically. Frankly, technology problems are easily solved, and organizational problems are often hidden. The biggest obstacle is fear of change. Somebody said, “Change is inevitable; progress is not.” Somebody else said, “Change is inevitable except from a vending machine.” So, whatever view you take, you can make progress, but only if you confront the people and organizational issues squarely.

Marv Patterson of Hewlett Packard put together a chart showing factors that encourage process change but do not necessarily create it. You have to have high-level endorsement. You must have the visibility of metrics. You have to have grassroots involvement, and you have to have the motivation of success stories. People are, in fact, the key.

Appendixes

Appendix A

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APPENDIX B

Agenda

LINKING THE CONSTRUCTION INDUSTRY: ELECTRONIC OPERATION AND MAINTENANCE MANUALS

October 13, 1999

Lecture Room
National Academy of Sciences Building
Washington, D.C.

7:30-8:30 a.m.	**Continental Breakfast and Registration**
8:30-8:45 a.m.	**Welcome/Review of Workshop Objectives and Project Funding** Mr. Bill Brodt, Acting Chief, Materials Acquisition and Supply Section, Division of Engineering Services, National Institutes of Health
8:45-9:15 a.m.	**Purpose and a Vision for the Electronic Operation and Maintenance Manual Initiative** Mr. Eli Katz, Consultant

9:15-10:00 a.m.	**Experience with Electronic Operation and Maintenance Manuals in the Auto Industry** The speaker will focus on his experience in developing and publishing electronic operation and maintenance manuals for the automobile industry and give his perspectives on the potential for transferring this experience to the building industry. Mr. Ken Poirer, Tweddle Litho Company
10:00-10:15 a.m.	**Break**
10:15-10:45 a.m.	**Demonstration of Prototype Practice for the Building Industry** Mr. Eric Jackson, Industrial Engineer, Atlantic Division, Naval Facilities Engineering Command
10:45-10:55 a.m.	**Purpose and Format of Facilitated Breakout Sessions** Mr. Dana K. “Deke” Smith, AIA, Deputy Director, Navy Y2K Ashore and Advanced Engineering Systems, Chair, NIBS, Facility Information Council, Naval Facilities Engineering Command
11:10–12:30 p.m.	**Facilitated Breakout Sessions** Stakeholder perspectives on potential costs and benefits of the prototype practice, potential audience and market for this technology, technological and economic barriers to implementation of the prototype as a recommended industry practice; methods and strategies for overcoming identified barriers.
12:30–1:30 p.m.	**Lunch**
1:30-2:00 p.m.	**Emerging Technologies and a Vision for the Future** Mr. Joel Orr, Joel Orr Consultants
2:00-3:30 p.m.	**Identification of Potential Implementation Strategies, Pilot Projects, Next Steps** Facilitated breakout sessions
3:30–3:45 p.m.	**Break**
3:45-4:15 p.m.	**Synthesis of Issues and Implementation Strategies; Consensus Findings of the Workshop; Wrapup and Next Steps** Facilitators and Mr. Bill Brodt, National Institutes of Health
4:15 p.m.	**Adjourn**

APPENDIX C

Document Type Definition Document

Document Type Definition (DTD)

```
<!-- The formal public identifier for the following set of declarations
comprising the "docomsi" DTD is:

<!DOCTYPE docomsi PUBLIC "-//USA-DOD//DTD FOR FACILITIES OPERATION AND
MAINTENANCE MANUALS 980309//EN"> -->

<!-- To parse the "docomsi" DTD, place "<!DOCTYPE docomsi [" at the beginning
of this file and "]>" at the end of this file. -->

<!--
     This document type definition (DTD) models the documents proposed to
implement the Operation and Maintenance Support Information (OMSI) concept
initiated by the Naval Facilities Engineering Command (NAVFACENGCOM) and the
Public Health Service to improve the operation and maintenance of facilities.
This DTD is based on: (1) an analysis and modelling of the of the seven volume
sample document "Building 1579 Bachelor Enlisted Quarters Norfolk Naval
Shipyard"; (2) some King's Bay material; and (3) information/guidance provided
by NAVFACENGCOM. Also certain commonly used CALS SGML constructs (element,
attribute, entity definitions, etc.) from tables I and II of MIL-PRF-28001B
(the CALS SGML performance specification) were used as appropriate to complete
the modelling. For further information concerning the OMSI concept or the
availability of this DTD (which is in the preliminary draft stage) contact
either:

   Dr. William Brodt                       Mr. Eric Jackson
   301-496-4941                            757-322-4616
   brodtb@des13.od.nih.gov                 jacksonea@edflant.navfac.navy.mil
   FAX: 301-402-7182                       FAX: 757-322-4614

     This DTD was written for NAVFACENGCOM by the Technology Implementation
Support Team of the Naval Surface Warfare Center, Carderock Division. For
information regarding this DTD, contact either:

   Ms. Lori Westbrook                      Mr. Donald Gignac
   301-227-3346                            301-227-3348
   westbroo@dt.navy.mil                    gignac@dt.navy.mil

of the

   Technology Implementation Support Team (NSWCCD Code 2053)
   Naval Surface Warfare Center
   Carderock Division
   9500 MacArthur Boulevard
   West Bethesda, MD 20817-5700.

whose FAX number is 301-227-3343. -->

<!-- START OF DOCOMSI DTD -->

<!-- COMMONLY USED CALS PARAMETER ENTITIES -->
<!-- TEXT COMPONENTS -->
<!ENTITY % text "(#PCDATA | subscrpt | supscrpt | emphasis | xref | graphic |
                  extref)+">
```

Document Type Definition (DTD)

```
<!-- LIST OPTIONS -->
<!ENTITY % list "seqlist | deflist | randlist">

<!-- PARAGRAPH CONTENT -->
<!ENTITY % paracon "paratext | %list;">

<!-- YES OR NO ATTRIBUTE VALUE -->
<!ENTITY % yesorno "NUMBER">
<!-- END OF COMMONLY USED CALS PARAMETER ENTITIES -->

<!-- OMSINFO: OPERATIONS MAINTENANCE & SUPPORT INFORMATION -->
<!ELEMENT docomsi  - -  (facinfo, sysinfo, proddata)>

<!-- FACINFO: FACILITY INFORMATION -->
<!ELEMENT facinfo  - -  (preface, mtoc, genfac-sysdes, basdes, safhaz, flplans,
                         utilplans, extwarinfo, equipinvent, hvacfilts,
                         flcovers, wallcovers, ceilsurfs, windows, ltfixts,
                         plumbfixts, roofing, supinvreqs, man-supp-contract?,
                         abdrawlist, trainreqs, skillmatrix)
                       +(table | graphic)>

<!-- PREFACE: PREFACE -->
<!ELEMENT preface  - -  (para0+)
                       -(table | graphic)>

<!-- MTOC: AUTOMATICALLY GENERATED MASTER TABLE OF CONTENTS -->
<!ELEMENT mtoc  - O  EMPTY>

<!-- GENFAC-SYSDES: GENERAL FACILITY & SYSTEM DESCRIPTION -->
<!ELEMENT genfac-sysdes  - -  (facdes, syst+)>

<!-- FACDES: FACILITY DESCRIPTION -->
<!ELEMENT facdes  - -  (para0+)>

<!-- SYST: NAME OF FACILITY SYSTEM -->
<!ELEMENT syst  - -  (title, para0+)>
<!-- "idref" on "sys" links to "id" on corresponding system -->
<!ATTLIST syst  idref   IDREF   #IMPLIED>

<!-- BASDES: BASIS OF DESIGN -->
<!ELEMENT basdes  - -  (para0+)>

<!-- SAFHAZ: SAFETY HAZARDS -->
<!ELEMENT safhaz  - -  (para0+)>

<!-- FLPLANS: FLOOR PLANS
     UTILPLANS: UTILITY CONNECTION AND CUTOFF PLANS -->
<!ELEMENT (flplans | utilplans)  - -  (para0 | table | graphic)*>

<!-- EXTWARINFO: COLLECTION OF EXTENDED WARRANTY INFORMATION -->
<!ELEMENT extwarinfo  - -  (para0*, extwarrant*)>

<!-- EXTWARRANT: EXTENDED WARRANTY INFORMATION -->
<!ELEMENT extwarrant  - -  (extwarrantline)+>
```

Document Type Definition (DTD)

```
<!-- EXTWARRANTLINE: LINE OF EXTENDED WARRANTY INFORMATION -->
<!ELEMENT extwarrantline  - -  (title, specsect, duration, startdate, enddate,
                                poc)>

<!-- SPECSECT: RELEVANT SPECIFICATION SECTION
     DURATION: DURATION OF WARRANTY
     STARTDATE: START DATE OF WARRANTY
     ENDDATE: END DATE OF WARRANTY -->
<!ELEMENT (specsect | duration | startdate | enddate)  - -  (#PCDATA)>

<!-- POC: POINT OF CONTACT -->
<!ELEMENT poc  - -  (mfr | supplier | contractor | subcontractor | installer)>

<!-- WINDOWS: WINDOWS
     HVACFILTS: HVAC FILTERS
     FLCOVERS: FLOOR COVERINGS
     WALLCOVERS: WALL COVERINGS
     CEILSURFS: CEILING SURFACES -->
<!ELEMENT (windows | hvacfilts | flcovers | wallcovers | ceilsurfs)
                                                              - -  (para0*)>
<!-- ROOFING: ROOFING -->
<!ELEMENT roofing  - -  (para0*, poc?, contractor?, subcontractor?,
                         installer?)>

<!-- EQUIPINVENT: EQUIPMENT INVENTORY - CONTENT MODEL -->
<!ELEMENT equipinvent  - -  (equip*)>

<!-- EQUIP: PIECE OF EQUIPMENT -->
<!ELEMENT equip  - -  (title, equipline+)>

<!-- EQUIPLINE: LINE OF EQUIPMENT INFORMATION -->
<!ELEMENT equipline  - -  (equipdes, location?, modelno, tagno?, serno?, mfr?,
                           supplier?)>

<!-- TAGNO: TAG NUMBER
     SERNO: SERIAL NUMBER -->
<!ELEMENT (tagno | serno)  - -  CDATA>

<!-- EQUIPDES: EQUIPMENT DESCRIPTION
     LOCATION: LOCATION
     MODELNO: MODEL NUMBER (CALS)
     PARTNO: PART NUMBER (CALS) -->
<!ELEMENT (equipdes | location | modelno | partno)  - -  (%text;)>
<!ATTLIST (modelno | partno)  label  CDATA  #IMPLIED
                              id     ID     #IMPLIED
                              idref  IDREF  #IMPLIED>

<!-- MFR: MANUFACTURE (CALS)
     SUPPLIER: SUPPLIER -->
<!ELEMENT (mfr | supplier | contractor | subcontractor | installer)  - -
                                                   (name, address, phone)>
```

Document Type Definition (DTD)

```
<!ATTLIST (mfr | supplier | contractor | subcontractor | installer)
                                          label   CDATA   #IMPLIED
                                          id      ID      #IMPLIED
                                          idref   IDREF   #IMPLIED>

<!-- NAME: NAME
     ADDRESS: ADDRESS
     PHONENO: PHONE NUMBER -->
<!ELEMENT (name | address | phone)  - -  (%text;)>

<!-- LTFIXTS: LIGHTING FIXTURES
     PLUMBFIXTS: PLUMBING FIXTURES -->
<!ELEMENT (ltfixts | plumbfixts)  - -  (para0*)>

<!-- SUPINVREQS: SUPPLY INVENTORY REQUIREMENTS -->
<!ELEMENT supinvreqs  - -  (trade*)>

<!-- TRADE: TRADE -->
<!ELEMENT trade  - -  (title, (partdes, partno, qty, equipusedon, name,
                               address, phone)+)>

<!-- EQUIPUSEDON: EQUIPMENT USED ON -->
<!ELEMENT equipusedon  - -  (seqlist?)>

<!-- MAN-SUPP-CONTRACT: MANUFACTURERS, SUPPLIERS, AND
     CONTRACTORS/SUBCONTRACTORS -->
<!ELEMENT man-supp-contract  - -  (para0+)>

<!-- ABDRAWLIST: AS-BUILT DRAWING LIST -->
<!ELEMENT abdrawlist  - -  (para0*, table*)>

<!-- TRAINREQS: TRAINING REQUIREMENTS -->
<!ELEMENT trainreqs  - -  (title, reqtrain, oprec?)>
<!ATTLIST trainreqs  system   IDREFS    #REQUIRED>

<!-- REQTRAIN: REQUIRED TRAINING -->
<!ELEMENT reqtrain  - -  (mfr, descrip+)+>

<!-- DESCRIP: TRAINING DESCRIPTION
     OPRECS: OPTIONAL RECOMMENDATIONS -->
<!ELEMENT (descrip | oprec)  - -  (para0+)>

<!-- SKILLMATRIX: SKILL MATRIX -->
<!ELEMENT skillmatrix  - -  (para0*, table)>

<!-- SYSINFO: PRIMARY SYSTEMS INFORMATION -->
<!ELEMENT sysinfo  - -  (system+) +(table | graphic)>

<!-- SYSTEM: SYSTEM -->
<!ELEMENT system  - -  (operation, prevmaint, repair, man-data)
                      +(warning | caution | note)>
<!-- "id" links to "idref" on corresponding "syst" -->
<!ATTLIST system  id   ID   #REQUIRED>
```

Document Type Definition (DTD)

```
<!-- OPERATION: OPERATION -->
<!ELEMENT operation  - -  (sysdes, start-shut, normal, flowdia, diaplan,
                           emergency, environment, fieldtestreps?, opservreq,
                           safeinst, valvelist, oplog, calprocs?)>

<!-- SYSDES: SYSTEM DESCRIPTION -->
<!ELEMENT sysdes  - -  (para0+)>

<!-- START-SHUT: START-UP AND SHUTDOWN PROCEDURES -->
<!ELEMENT start-shut  - -  (para0*, start-up, shutdown)+>

<!-- START-UP: START-UP PROCEDURES
     SHUTDOWN: SHUTDOWN PROCEDURES -->
<!ELEMENT (start-up | shutdown)  - -  (para0*, step1+)>

<!-- NORMAL: NORMAL OPERATING INSTRUCTIONS -->
<!ELEMENT normal  - -  (para0+)>

<!-- FLOWDIA: SYSTEM FLOW DIAGRAMS
     DIAPLAN: DIAGRAMMATIC PLANS -->
<!ELEMENT (flowdia | diaplan)  - -  (para0*, graphic+)>

<!-- EMERGENCY: EMERGENCY OPERATING INSTRUCTIONS -->
<!ELEMENT emergency  - -  (para0*, step1*)>

<!-- FIELDTESTREP: FIELD TEST REPORT
     ENVIRONMENT: ENVIROMENTAL CONSIDERATIONS
     OPSERVREQ: OPERATOR SERVICING REQUIREMENTS
     SAFEINST: SAFETY INSTRUCTIONS -->
<!ELEMENT (fieldtestreps | environment | opservreq | safeinst)  - -  (para0+)>

<!-- VALVELIST: VALVE LIST -->
<!ELEMENT valvelist  - -  (para0*, (table | graphic)* )>

<!-- OPLOG: OPERATING LOGS -->
<!ELEMENT oplog  - -  (para0, graphic+)+>

<!-- CALPROCS: CALIBRATION PROCEDURES -->
<!ELEMENT calprocs  - -  (para0, step1*)+>

<!-- PREVMAINT: PREVENTIVE MAINTENANCE PROCEDURES -->
<!ELEMENT prevmaint  - -  (plan-sched, pmproc, pmlog, lube)>

<!-- PLAN-SCHED: PREVENTIVE MAINTENANCE PLAN & SCHEDULE -->
<!ELEMENT plan-sched  - -  (para0 | graphic)+>

<!-- PMPROC: PREVENTIVE MAINTENANCE PROCEDURES -->
<!ELEMENT pmproc  - -  (para0*, taskcard+)>

<!-- INTRO: INTRODUCTION TO PREVENTATIVE MAINTENANCE PROCEDURES -->
<!ELEMENT intro  - -  (para0+)>

<!-- TASKCARD: WORK ORDER TASK CARD -->
<!ELEMENT taskcard  - -  (graphic)>
```

Document Type Definition (DTD)

```
<!ATTLIST taskcard  system   CDATA   #REQUIRED>

<!-- PMLOG: PREVENTIVE MAINTENANCE LOG
     LUBE: LUBRICATION SCHEDULE -->
<!ELEMENT (pmlog | lube)  - -  (para0*, graphic*)>

<!-- REPAIR: REPAIR -->
<!ELEMENT repair  - -  (ts-diag, rproc, rem-rep, rlog)>

<!-- TS-DIAG: TROUBLESHOOTING & DIAGNOSTICS
     RPROC: REPAIR PROCEDURES
     REM-REP: REMOVAL & REPLACEMENT INSTRUCTIONS -->
<!ELEMENT (ts-diag | rproc | rem-rep)  - -  (para0+, (table | graphic)*)>

<!-- RLOG: REPAIR LOG -->
<!ELEMENT rlog  - -  (para0+)>

<!-- MAN-DATA:  MANUFACTURER'S DATA -->
<!ELEMENT man-data  - -  (mdop-maint, meqinfo)>

<!-- MDOP-MAINT: MANUFACTURER'S OPERATING AND MAINTENANCE DATA
     MEQINFO: MANUFACTURER'S EQUIPMENT INFORMATION -->
<!ELEMENT (mdop-maint | meqinfo)  - -  (para0?, graphic)+>

<!-- PRODDATA: PRODUCT DATA -->
<!ELEMENT proddata  - -  (sectinfo+)>

<!-- SECTINFO: CSI MASTERFORMAT SECTION NUMBER -->
<!ELEMENT sectinfo  - -  (prodinfo*)>
<!-- label required to provide "02000 - SITE WORK" (for example) -->
<!ATTLIST sectinfo  label      CDATA       #REQUIRED
  -- "reserved" allows for "This section reserved for future use."
      remember this is a deprecated practice --
                   reserved   (yes)       #CONREF>

<!-- PRODINFO: PRODUCT INFORMATION -->
<!ELEMENT prodinfo  - -  (title?, cutsheet*, mdop-maint?, warranty*)>

<!-- CUTSHEET: PRODUCT SHEETS/SPECIFICATIONS -->
<!ELEMENT cutsheet  - -  (partdes, name, modelno, partno, qty, unit, measure,
                          tools, partlist, applicabil)
                        +(graphic)>

<!-- MEASURE: MEASUREMENT SYSTEM -->
<!ELEMENT measure  - - (impmeas*, simeas*)>

<!-- IMPMEAS: IMPERIAL MEASURE
     SIMEAS: SI MEASURE -->
<!ELEMENT (impmeas | simeas)  - -  (unit, qty)>

<!-- UNIT: UNIT
     QTY: QUANTITY -->
<!ELEMENT (unit | qty)  - -  (#PCDATA)>
```

Document Type Definition (DTD)

```
<!-- TOOLS: TOOLS -->
<!ELEMENT tools  - -  (para0*)>

<!-- APPLICABIL: APPLICABILITY -->
<!ELEMENT applicabil  - -  (partdes, name, modelno, partno)*>

<!-- PARTLIST: PART LIST -->
<!ELEMENT partlist  - -  (%list;)+>

<!-- WARRANTY: WARRANTY INFORMATION -->
<!ELEMENT warranty  - -  (partdes, title, modelno, partno)
                        +(graphic)>
<!ATTLIST warranty  type   (system | component)   #IMPLIED>

<!-- PARTDES: PART DESCRIPTION -->
<!ELEMENT partdes  - -  (para0 | graphic | %list;)*>

<!-- BASIC CALS ELEMENTS -->
<!-- Primary Paragraph -->
<!ELEMENT para0  - -  (title?, para+, subpara1*)>
<!ATTLIST para0  id        ID        #IMPLIED
                 label     CDATA     #IMPLIED>

<!-- Paragraph Text (Must Not Contain Lists) -->
<!ELEMENT paratext  - -  (%text;)+>

<!-- Untitled Paragraph (Contains Paragraph Text and/or Lists) -->
<!ELEMENT para  - -  (paratext | %list; | table)+>

<!-- First Order Subparagraph -->
<!ELEMENT subpara1  - -  (title?, para+)>

<!-- First Order Procedural Step -->
<!ELEMENT step1  - -  ((para | warning | caution | note)+, step2*)>

<!-- Second Order Procedural Step -->
<!ELEMENT step2  - -  ((para | warning | caution | note)+, step3*)>

<!-- Third Order Procedural Step -->
<!ELEMENT step3  - -  ((para | warning | caution | note)+, step4*)>

<!-- Fourth Order Procedural Step -->
<!ELEMENT step4  - -  ((para | warning | caution | note)+, step5*)>

<!-- Fifth Order Procedural Step -->
<!ELEMENT step5  - -  ((para | warning | caution | note)+, step6*)>

<!-- Sixth Order Procedural Step -->
<!ELEMENT step6  - -  ((para | warning | caution | note)+, step7*)>

<!-- Seventh Order Procedural Step -->
<!ELEMENT step7  - -  (para | warning | caution | note)+>
```

Document Type Definition (DTD)

```
<!-- Cross-Reference within a Document -->
<!ELEMENT xref  - O  EMPTY>
<!ATTLIST xref  xrefid        IDREF                          #REQUIRED
                xidtype       (figure | table | text)        #REQUIRED
                pretext       CDATA                          #IMPLIED
                posttext      CDATA                          #IMPLIED>

<!-- Reference of an External Document -->
<!ELEMENT extref   - o  EMPTY >
<!ATTLIST extref  docno        CDATA        #IMPLIED
                  pretext      CDATA        #IMPLIED
                  posttext     CDATA        #IMPLIED>

<!-- Special Paragraph Text: Warning / Caution / Note -->
<!ELEMENT (warning | caution | note)  - -  (%paracon; | table)+>
<!ATTLIST (warning | caution)   id       ID        #IMPLIED
                                idref    IDREF     #IMPLIED
                                label    CDATA     #IMPLIED
                                xlink    CDATA     #IMPLIED>
<!ATTLIST note  id       ID        #IMPLIED
                idref    IDREF     #IMPLIED
                label    CDATA     #IMPLIED
                xlink    CDATA     #IMPLIED
                prefix   CDATA     #IMPLIED>

<!-- Generic Title -->
<!ELEMENT title  - -  (%text;)+>
<!ATTLIST title  id       ID      #IMPLIED
                 label    CDATA   #IMPLIED>

<!-- Sequential List -->
<!ELEMENT seqlist  - -  (title?, item+)>
<!ATTLIST seqlist    id          ID                      #IMPLIED
                     label       CDATA                   #IMPLIED
                     numstyle    (none |
                                  arabic |
                                  alphalc |
                                  arabic-parens |
                                  alphalc-parens |
                                  arabic-dashes |
                                  alphalc-dashes)        #IMPLIED>
<!-- Random List -->
<!ELEMENT randlist  - -  (title?, item+)>
<!ATTLIST randlist  prefix      CDATA    #IMPLIED>

<!-- Sequential \ Random List Item -->
<!ELEMENT item  - -  (%paracon; | table | chart)+>
<!ATTLIST item  id          ID                #IMPLIED
                label       CDATA             #IMPLIED
                idref       IDREF             #IMPLIED
                spinno      CDATA             #IMPLIED>
<!-- Graphic -->
```

Document Type Definition (DTD)

```
<!ELEMENT graphic  - o  EMPTY>
<!ATTLIST graphic  boardno     ENTITY     #REQUIRED
                   id          ID         #IMPLIED
                   label       CDATA      #IMPLIED>

<!-- Subscript / Superscript -->
<!ELEMENT (subscrpt | supscrpt)  - -  CDATA>

<!-- Definition List -->
<!ELEMENT deflist  - - (title?, (term, def)+)>

<!-- Term To Be Defined in Definition List -->
<!ELEMENT term  - -  (%text;)+>

<!-- Definition of Term in Definition List -->
<!ELEMENT def  - -  (%paracon; | table)+>

<!-- Emphasis -->
<!ELEMENT emphasis  - -  (%text;)+>
<!ATTLIST emphasis  type   (bold | underline)   #REQUIRED>

<!-- CALS Table Model (Modified to Allow Title Above or Below) -->
<!ELEMENT (table | chart)  - -  ((title, tgroup+) | (tgroup+, title?))
                                -(table | chart)>
<!ATTLIST (table | chart)  frame       (top | bottom | topbot |
                                        all | sides | none)        #IMPLIED
                           colsep      %yesorno;                   #IMPLIED
                           rowsep      %yesorno;                   #IMPLIED
                           orient      (port | land)               #IMPLIED
                           pgwide      %yesorno;                   #IMPLIED
                           id          ID                          #IMPLIED
                           calltable   %yesorno;                   #IMPLIED>
<!-- Table Group -->
<!ELEMENT tgroup  - o  (colspec*, spanspec*, thead?, tfoot?, tbody) >
<!ATTLIST tgroup  cols         NUMBER                         #REQUIRED
                  colsep       %yesorno;                      #IMPLIED
                  rowsep       %yesorno;                      #IMPLIED
                  align        (left | right | center |
                                justify | char)               "left"
                  charoff      NUTOKEN                        "50"
                  char         CDATA                          "">

<!-- Column Specification -->
<!ELEMENT colspec  - o  EMPTY>
<!ATTLIST colspec  colnum       NUMBER                        #IMPLIED
                   colname      NMTOKEN                       #IMPLIED
                   align        (left | right | center |
                                 justify | char)              #IMPLIED
                   charoff      NUTOKEN                       #IMPLIED
                   char         CDATA                         #IMPLIED
                   colwidth     CDATA                         #IMPLIED
                   colsep       %yesorno;                     #IMPLIED
                   rowsep       %yesorno;                     #IMPLIED>
<!-- Span Specification -->
```

Document Type Definition (DTD)

```
<!ELEMENT spanspec   - o  EMPTY >
<!ATTLIST spanspec  namest       NMTOKEN                      #REQUIRED
                    nameend      NMTOKEN                      #REQUIRED
                    spanname     NMTOKEN                      #REQUIRED
                    align        (left | right | center |
                                  justify | char)             "center"
                    charoff      NUTOKEN                      #IMPLIED
                    char         CDATA                        #IMPLIED
                    colsep       %yesorno;                    #IMPLIED
                    rowsep       %yesorno;                    #IMPLIED>

<!-- Table Head / Table Foot -->
<!ELEMENT (thead | tfoot)  - o  (colspec*, row+) -(entrytbl) >
<!ATTLIST thead  valign     (top | middle | bottom)     "bottom">
<!ATTLIST tfoot  valign     (top | middle | bottom)     "top">

<!-- Table Body -->
<!ELEMENT tbody  - o  (row+)>
<!ATTLIST tbody  valign     (top | middle | bottom)     "top">

<!-- Table Row -->
<!ELEMENT row  - o  (entry | entrytbl)+ >
<!ATTLIST row  rowsep     %yesorno;     #IMPLIED>

<!-- Table Row Entry / Component Description Box Entry -->
<!ELEMENT entry  - -  (paratext | %list;)+>
<!ATTLIST entry  colname       NMTOKEN                      #IMPLIED
                 namest        NMTOKEN                      #IMPLIED
                 nameend       NMTOKEN                      #IMPLIED
                 spanname      NMTOKEN                      #IMPLIED
                 morerows      NUMBER                       "0"
                 colsep        %yesorno;                    #IMPLIED
                 rowsep        %yesorno;                    #IMPLIED
                 rotate        %yesorno;                    "0"
                 valign        (top | bottom | middle)      "top"
                 align         (left | right | center |
                                justify | char)             #IMPLIED
                 charoff       NUTOKEN                      #IMPLIED
                 char          CDATA                        #IMPLIED
                 idref         IDREF                        #IMPLIED>

<!-- Entry Table -->
<!ELEMENT entrytbl  - -  (colspec*, spanspec*, thead?, tbody)+ -(entrytbl)>
<!ATTLIST entrytbl  cols        NUMBER                      #REQUIRED
                    colname     NMTOKEN                     #IMPLIED
                    spanname    NMTOKEN                     #IMPLIED
                    colsep      %yesorno;                   #IMPLIED
                    rowsep      %yesorno;                   #IMPLIED
                    align       (left | right | center |
                                 justify | char)            #IMPLIED
                    charoff     NUTOKEN                     #IMPLIED
                    char        CDATA                       #IMPLIED>
<!-- End of CALS Table Model -->
<!-- END OF BASIC CALS ELEMENTS -->
```

Document Type Definition (DTD)

```
<!-- START OF DATA CONTENT NOTATION DECLARATIONS -->
<!-- Each of the following notations provides a capability for accessing
and processing graphical data of a certain type. -->
<!NOTATION cgmbin PUBLIC "ISO 8632/3//NOTATION CGM Binary text encoding//EN">

<!NOTATION iges PUBLIC "-//USA-DOD//NOTATION (ASME/ANSI Y14.26M-1987) Initial
                                  Graphics Exchange Specification//EN">

<!NOTATION fax PUBLIC "-//USA-DOD//NOTATION CCITT Group 4 Facsimile Type1
                                                 Untiled Raster//EN">

<!NOTATION faxtile PUBLIC "-//USA-DOD//NOTATION CCITT Group 4 Facsimile
                                          Type 2 Tiled Raster//EN">

<!NOTATION tif SYSTEM>
<!-- END OF DATA CONTENT NOTATION DECLARATIONS -->

<!-- START OF ISO CHARACTER SET DECLARATIONS -->
<!-- The SDATA (system dependent) character declarations contained in these
character sets enable the non-keyboard characters for the application software.
They also allow SGML delimiters to be used as character data. -->
<!ENTITY % ISOlat1 PUBLIC "ISO 8879:1986//ENTITIES Added Latin 1//EN">

<!ENTITY % ISOpub PUBLIC "ISO 8879:1986//ENTITIES Publishing//EN">

<!ENTITY % ISOgrk1 PUBLIC "ISO 8879:1986//ENTITIES Greek Letters//EN">

<!ENTITY % ISOgrk3 PUBLIC "ISO 8879:1986//ENTITIES Greek Symbols//EN">

<!ENTITY % ISOnum PUBLIC "ISO 8879:1986//ENTITIES Numeric and Special
                                                       Graphic//EN">

<!ENTITY % ISOtech PUBLIC "ISO 8879:1986//ENTITIES General Technical//EN">

%ISOlat1; %ISOpub; %ISOgrk1; %ISOgrk3; %ISOnum; %ISOtech;
<!-- END OF ISO CHARACTER SET DECLARATIONS -->

<!-- TABBING CAPABILITY -->
<!-- Some SGML application software does not provide a tabbing capability
(i.e., the spacing obtained by pressing the TAB key). Referencing the "tab"
general entity below provides a 5-space TAB. -->
<!ENTITY tab "     ">

<!-- END OF DOCOMSI DTD -->
```

APPENDIX D

Naval Facilities Engineering Command Guide Specification 01781

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DEPARTMENT OF THE NAVY	**NFGS-01781C**
NAVAL FACILITIES	**31 March 1998**
ENGINEERING COMMAND	**------------------------------**
GUIDE SPECIFICATION	**Superseding NFGS-01781B (09/96)**

****

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03/98

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**************************************************************************
DEPARTMENT OF THE NAVY                  NFGS-01781C
NAVAL FACILITIES                        31 March 1998
ENGINEERING COMMAND                     ------------------------------
GUIDE SPECIFICATION                     Superseding NFGS-01781B (09/96)
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NFGS-01781C

OPERATION AND MAINTENANCE DATA

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**************************************************************************
*                                                                        *
* Preparing Activity: LANTNAVFACENGCOM                                   *
*                                                                        *
*             Typed Name & Reg.         Signature          Date          *
*                                                                        *
*                                                                        *
* Prepared by: P. C. DaVia, P.E.          /s/              12/02/97      *
*                                                                        *
*                                                                        *
* Approved by: E. J. Gallaher, P.E.       /s/              01/13/98      *
*              Branch Manager                                            *
*                                                                        *
*                                                                        *
* Approved by: W. H. Crone, P.E.          /s/              01/15/98      *
*              Division Director                                         *
*                                                                        *
*                                                                        *
* Approved for NAVFAC:    /s/                              03/31/98      *
*                    Carl E. Kersten, R.A.                               *
*                                                                        *
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AMSC N/A                                                        AREA FACR
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DEPARTMENT OF THE NAVY	NFGS-01781C
NAVAL FACILITIES	31 March 1998
ENGINEERING COMMAND	------------------------------
GUIDE SPECIFICATION	Superseding NFGS-01781B (09/96)

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SECTION 01781

OPERATION AND MAINTENANCE DATA
03/98

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NOTE: This guide specification covers Contractor submittal requirements for Data Packages necessary to form the basis for Architect-Engineer (A/E) preparation of facility Operating and Maintenance Support Information (OMSI) Manuals. The prefinal OMSI Manuals should be complete 30 to 60 days before construction acceptance/beneficial occupancy and will be used for operation and maintenance of the facility pending final OMSI completion (approximately 6 months after beneficial occupancy).

Responsibilities for providing Operation and Maintenance (O&M) Data Packages and, finally, OMSI Manuals will normally be as follows:

1. Project Contractor: Provides Data Package submittals from suppliers and manufacturers to meet the requirements of this guide specification.

a. Manufacturer's Cut-Sheets: These submittals are the standard product data available from manufacturers for individual pieces of equipment or components. This data describes and identifies the product but does not normally provide detailed operation, maintenance, and repair information.

b. Supplier/manufacturer O&M Data and/or Manuals: Equipment or components used in facility construction (including many architectural products) have manufacturer's specific instructions and procedures for proper operation, maintenance and repair of the items. This information is needed at the time of occupancy and ofter be specially obtained by the construction Contractor from suppliers/manufacturers at the time of purchase. Refer to paragraph titled "Schedule of Operation and Maintenance Data Packages." If the product is a "package" system such as diesel electric generator, the supplier or manufacturer can also provide a manual or data that covers a complete system of interrelated components, including interconnecting wiring diagrams, narrative system control sequences,

and system operating, maintenance, and repair instructions. The requirements for all O&M Data/Manuals should be completely specified by the designer in the individual technical section which covers the particular system under the "SD-19" submittal designation.

2. Architect/Engineer: (normally the project designer): Reviews and assembles all Contractor-furnished submittals, prepares and expands on systems operation, maintenance, and repair discussions. The A/E finalizes the OMSI Manuals for the facility user/maintainer by providing such items as illustrations, photographs, utility connection plans, and indexes. Also, preparer will include Contractor submittals such as Shop Drawings, Manufacturer Cut Sheets, Test Reports and Extended Warranties. The objectives of OMSI are to produce high quality, "user friendly," comprehensive manuals which are essentially complete just prior to facility acceptance and reflect the as-built products and systems.

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NOTE: This revision "C" to NFGS-01781 revalidates the issue dated 30 September 1996.

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PART 1 GENERAL

1.1 SUBMISSION OF OPERATION AND MAINTENANCE DATA

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NOTE: The provisions of this section apply only to those items requiring operation and maintenance by the technical sections. The technical sections should include a paragraph titled "SD-19, Operation and Maintenance Manuals," stating: "Submit Operation and Maintenance Data in accordance with Section 01781, "Operations and Maintenance Data," Data Package [1] [2] [3] [4] [5]. Operation, maintenance, and repair requirements peculiar to certain equipment shall also be specified in the pertinent technical section.

****

Submit Operation and Maintenance (O&M) Data/Manuals which are specifically applicable to this contract and a complete and concise depiction of the provided equipment or product. Organize and present information in sufficient detail to clearly explain O&M requirements at the system, equipment, component, and subassembly level. Include an index preceding each submittal. Submit in accordance with this section and Section 01330, "Submittal Procedures."

1.1.1 Quantity

****

NOTE: For LANTNAVFACENGCOM projects, submit three copies.

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Submit [five] sets of the supplier/manufacturers' O&M information specified herein for the components, assemblies, subassemblies, attachments, and accessories. The items for which O&M Data/Manuals are required are listed in the technical sections which specifies those particular items.

1.1.2 Package Quality

Documents must be fully legible. Poor quality copies and material with hole punches obliterating the text or drawings will not be accepted.

1.1.3 Package Content

Data package content shall be as shown in the paragraph titled "Schedule of Operation and Maintenance Data Packages." For each product, system, or component piece of equipment requiring submission of O&M Data, submit the Data Package specified in the individual technical section.

1.1.4 Delivery

Submit O&M Data Manuals to the Contracting Officer for review and acceptance; submit data specified for a given item within 30 calendar days after the item is delivered to the contract site.

a. In the event the Contractor fails to deliver O&M Data/Manuals within the time limits set forth above, the Contracting Officer may withhold from progress payments 50 percent of the price of the item with which such O&M Data/Manuals are associated.

1.1.5 Changes to Submittals

Manufacturer-originated changes or revisions to submitted data shall be furnished by the Contractor if a component of an item is so affected subsequent to acceptance of the O&M Data. Changes, additions, or revisions required by the Contracting Officer for final acceptance of submitted data, shall be submitted by the Contractor within 30 calendar days of the notification of this change requirement.

1.2 TYPES OF INFORMATION REQUIRED IN O&M DATA PACKAGES

****

NOTE: O&M Data needed for any product, system, or piece of equipment depends upon the complexity of that item. The types of O&M Data, defined below, are grouped into Data Packages in the paragraph titled "Schedule of Operation and Maintenance Data Packages." The Data Package numbers, in turn, appear in the technical guide specifications.

****

1.2.1 Operating Instructions

Include specific instructions, procedures, and illustrations for the following phases of operation:

1.2.1.1 Safety Precautions

List personnel hazards and equipment or product safety precautions for all operating conditions.

1.2.1.2 Operator Prestart

Include procedures required to set up and prepare each system for use.

1.2.1.3 Startup, Shutdown, and Postshutdown Procedures

Provide narrative description for each operating procedure including control sequence for each.

1.2.1.4 Normal Operations

Provide narrative description of normal operating procedures. Include control diagrams with data to explain operation and control of systems and specific equipment.

1.2.1.5 Emergency Operations

Include emergency procedures for equipment malfunctions to permit a short period of continued operation or to shut down the equipment to prevent further damage to systems and equipment. Include emergency shutdown instructions for fire, explosion, spills, or other foreseeable contingencies. Provide guidance on emergency operations of all utility systems including valve locations and portions of systems controlled.

1.2.1.6 Operator Service Requirements

Include instructions for services to be performed by the operator such as lubrication, adjustment, inspection, and gage reading recording.

1.2.1.7 Environmental Conditions

Include a list of environmental conditions (temperature, humidity, and other relevant data) which are best suited for each product or piece of equipment and describe conditions under which equipment should not be allowed to run.

1.2.2 Preventive Maintenance

Include the following information for preventive and scheduled maintenance to minimize corrective maintenance and repair.

1.2.2.1 Lubrication Data

Include lubrication data, other than instructions for lubrication in accordance with paragraph titled "Operator Service Requirements":

a. A table showing recommended lubricants for specific temperature ranges and applications;

b. Charts with a schematic diagram of the equipment showing lubrication points, recommended types and grades of lubricants, and capacities; and

c. A lubrication schedule showing service interval frequency.

1.2.2.2 Preventive Maintenance Plan and Schedule

Include manufacturer's schedule for routine preventive maintenance, inspections, tests and adjustments required to ensure proper and economical operation and to minimize corrective maintenance and repair. Provide manufacturer's projection of preventive maintenance work-hours on a daily, weekly, monthly, and annual basis including craft requirements by type of craft. For periodic calibrations, provide manufacturer's specified frequency and procedures for each separate operation.

1.2.3 Corrective Maintenance (Repair)

Include manufacturer's recommendations on procedures and instructions for correcting problems and making repairs.

1.2.3.1 Troubleshooting Guides and Diagnostic Techniques

Include step-by-step procedures to promptly isolate the cause of typical malfunctions. Describe clearly why the checkout is performed and what conditions are to be sought. Identify tests or inspections and test equipment required to determine whether parts and equipment may be reused or require replacement.

1.2.3.2 Wiring Diagrams and Control Diagrams

Wiring diagrams and control diagrams shall be point-to-point drawings of wiring and control circuits including factory-field interfaces. Provide a complete and accurate depiction of the actual job specific wiring and control work. On diagrams, number electrical and electronic wiring and pneumatic control tubing and the terminals for each type, identically to actual installation numbering.

1.2.3.3 Maintenance and Repair Procedures

Include instructions and list tools required to restore product or equipment to proper condition or operating standards.

1.2.3.4 Removal and Replacement Instructions

Include step-by-step procedures and list required tools and supplies for removal, replacement, disassembly, and assembly of components, assemblies, subassemblies, accessories, and attachments. Provide tolerances, dimensions, settings and adjustments required. Instructions shall include a combination of text and illustrations.

1.2.3.5 Spare Parts and Supply Lists

Include lists of spare parts and supplies required for maintenance and repair to ensure continued service or operation without unreasonable delays. Special consideration is required for facilities at remote locations. List spare parts and supplies that have a long lead time to obtain.

1.2.3.6 Corrective Maintenance Work-Hours

Include manufacturer's projection of corrective maintenance work-hours including craft requirements by type of craft. Corrective maintenance that requires participation of the equipment manufacturer shall be identified and tabulated separately.

1.2.4 Appendices

Provide information required below and information not specified in the preceding paragraphs but pertinent to the maintenance or operation of the product or equipment. Include the following:

1.2.4.1 Parts Identification

Provide identification and coverage for all parts of each component, assembly, subassembly, and accessory of the end items subject to replacement. Include special hardware requirements, such as requirement to use high-strength bolts and nuts. Identify parts by make, model, serial number, and source of supply to allow reordering without further identification. Provide clear and legible illustrations, drawings, and exploded views to enable easy identification of the items. When illustrations omit the part numbers and description, both the illustrations and separate listing shall show the index, reference, or key number which will cross-reference the illustrated part to the listed part. Parts shown in the listings shall be grouped by components, assemblies, and subassemblies. Parts data may cover more than one model or series of equipment. components, assemblies, subassemblies, attachments, or accessories, such as a master parts catalog, in accordance with the manufacturer's standard commercial practice.

1.2.4.2 Warranty Information

List and explain the various warranties and include the servicing and technical precautions prescribed by the manufacturers or contract documents to keep warranties in force. Include warranty information for primary components such as the compressor of air conditioning system.

1.2.4.3 Personnel Training Requirements

Provide information available from the manufacturers to use in training designated personnel to operate and maintain the equipment and systems properly.

1.2.4.4 Testing Equipment and Special Tool Information

Include information on test equipment required to perform specified tests and on special tools needed for the operation, maintenance, and repair of components.

1.2.4.5 Contractor Information

Provide a list that includes the name, address, and telephone number of the General Contractor and each subcontractor installing the product or equipment. Include local representatives and service organizations most convenient to the project site. Provide the name, address, and telephone number of the product or equipment manufacturers.

1.3 SCHEDULE OF OPERATION AND MAINTENANCE DATA PACKAGES

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NOTE: The type of O&M data needed for any product, system, or piece of equipment depends upon the complexity of that item. Normally the "Data Package" number will appear in the technical guide specification. If not, the specifier should include the appropriate Data Package number in the respective technical section, guided by the schedule in this paragraph in selecting the Data Package number. Data Package 1 would typically be used for architectural items requiring simple but specific maintenance and replacement; for example, acoustical ceiling, floor tile or carpeting system. Data Package 2 would be used for an item that is less simple; for example, an item having a motor and some sequence of operation such as a refrigerated drinking fountain. Data Package 3 would be used for a complex piece of equipment, having a specific troubleshooting sequence, but one which does not require an operator on watch; for example, HVAC temperature controls. Data Package 4 would be used for an extremely complex piece of equipment, having an extensive sequence of operation, a complex troubleshooting sequence and one requiring frequent operator attention; at least for start-up and shut-down. Examples of this case would be small boilers and small diesel generator sets. Finally, Data Package 5 would be used for electrical equipment, components or systems on which, wiring and control diagrams are needed for operation, maintenance or repair. Examples of this case are 400 Hz frequency converters, annunciator panels and cathodic protection systems.

****

Furnish the O&M Data Packages specified in individual technical sections. The required information for each O&M Data Package is as follows:

1.3.1 Data Package 1

a. Safety precautions

b. Maintenance and repair procedures

c. Warranty information

d. Contractor information

1.3.2 Data Package 2

a. Safety precautions

b. Normal operations

c. Environmental conditions

d. Lubrication data

e. Preventive maintenance plan and schedule

f. Maintenance and repair procedures

g. Removal and replacement instructions

h. Spare parts and supply list

i. Parts identification

j. Warranty information

k. Contractor information

1.3.3 Data Package 3

a. Safety precautions

b. Normal operations

c. Emergency operations

d. Environmental conditions

e. Lubrication data

f. Preventive maintenance plan and schedule

g. Troubleshooting guides and diagnostic techniques

h. Wiring diagrams and control diagrams

i. Maintenance and repair procedures

j. Removal and replacement instructions

k. Spare parts and supply list

l. Parts identification

m. Warranty information

n. Testing equipment and special tool information

o. Contractor information

1.3.4 Data Package 4

a. Safety precautions

b. Operator prestart

c. Startup, shutdown, and postshutdown procedures

d. Normal operations

e. Emergency operations

f. Operator service requirements

g. Environmental conditions

h. Lubrication data

i. Preventive maintenance plan and schedule

j. Troubleshooting guides and diagnostic techniques

k. Wiring diagrams and control diagrams

l. Maintenance and repair procedures

m. Removal and replacement instructions

n. Spare parts and supply list

o. Corrective maintenance man-hours

p. Parts identification

q. Warranty information

r. Personnel training requirements

s. Testing equipment and special tool information

t. Contractor information

1.3.5 Data Package 5

a. Safety precautions

b. Operator prestart

c. Start-up, shutdown, and post shutdown procedures

d. Normal operations

e. Environmental conditions

f. Preventive maintenance plan and schedule

g. Troubleshooting guides and diagnostic techniques

h. Wiring and control diagrams

i. Maintenance and repair procedures

j. Spare parts and supply list

k. Testing equipments and special tools

l. Warranty information

m. Contractor information

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

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NOTE: Suggestions for improvement of this specification will be welcomed using the Navy "Change Request Forms" subdirectory located in SPECSINTACT in Jobs or Masters under "Forms/Documents" directory or DD Form 1426. Suggestions should be forwarded to:

Officer In Charge
Seabee Logistics Center
NAVFAC 15G/SLC 15E
4111 San Pedro Street
Port Hueneme, CA 93043-4410

FAX: (805) 985-6465/922-5196 or DSN 551-5196

****

-- End of Section --