3 Workflow Process

Document Workflow Process: Overview

This section presents general workflow information common to both CADD and typical business documents first. Information on CADD-specific workflow follows the more general introductory information.

Workflow is the sequence and routing of tasks performed by members of a workgroup to complete a job. Discrete tasks performed by any workgroup are associated with particular documents and/or versions required to accomplish the task at hand and ultimately the job. Most of the daily responsibilities addressed by people within an organization are somehow related to the workflow process. Each task requires an action by a person or team before advancing a document to the next step in the workflow. Whether these tasks generate new information or are undertaken as part of a quality assurance process, a pre-defined or project-specific path determines the order of progress for the required tasks.

Workflows, often in the form of standard operating procedures, exist in every organization. Automation of the workflow process, whether structured or ad-hoc, results in a timely execution of tasks, minimizing the time-consuming and sometimes redundant activities of the typical business day. Using automated workflow, the sequence of tasks and subtasks are controlled and uniform with work in progress automatically routed to the appropriate recipients.

The potential benefit of an integrated and automated workflow within the document management function, unavailable in a repository-only system, is substantial. Automated workflows allow parallel and serial tasks as well as nested workflows. Task reassignment and rerouting are effectively implemented. Status updates, document review, revisions, and user comments become streamlined activities. Security and integrity of the documents progressing along the workflow path are maintained by implementing access rights and version control or managing the read and read/write control during the life cycle of the document. Audit trails and the subsequent reports are easily defined. Automated workflow saves time and money.

For automated workflow to occur, the software must account for many access and routing attributes. Established users and teams must be recognized by the system, along with the different levels of access rights and security for the documents being managed. Versioning or revision control (the ability of the system

to recognize updated versions of a document) must be enabled. The workflow must be able to recognize the required tasks or actions at each step along the project path and prevent the advancement of the document to the next step until all requirements have been met. (Intergraph Software Solutions, 1997)

Workflow can be either structured or ad-hoc. A structured workflow typically is designed to control repetitive activities, and bring order and control to such processes. A structured workflow may apply to situations in the world of finance or a major design project. Ad-hoc workflow also has a beginning and ending point. The difference is that ad-hoc workflow can be modified while the project or activity is in progress. CADD documents typically are associated with an ad-hoc workflow, since CADD document workflow is so dynamic. CADD workflow steps often are determined at the time document content changes or when documents pass through quality assurance, resulting in a dynamic, ad-hoc workflow.

Regardless of whether workflow is structured or ad-hoc, documents are distributed in one of three forms: image-based, form-based, or coordination-based. Image-based workflow, developed to reduce the flow of paper within a business, directs scanned images of paper documents through a structured cycle. Form-based systems manage text-based documents rather than scanned documents and require a more sophisticated workflow, one that senses the status of the text fields and routes the forms accordingly. The third workflow, coordination-based, is designed to optimize the human activities associated with situations including manufacturing and general office routines.

A list of desirable workflow attributes follows (Network Imaging Corporation, 1995), (FileNet Corporation, 1996) and (TSA/ADVET, 1996). Workflow should:

- Support existing networks, legacy data, personnel, and general business model
- Recognize predefined policies, standards, rules and conditions and incorporate rules-based safeguards
- Support graphical design and portrayal of workflow
- Address individual and grouped tasks
- Determine required task sequence and identify required skill sets per task
- Enforce document security via controlled access
- Automatically route and reroute documents
- Control/track document life cycle
- Launch native applications
- Adhere to a calendar schedule (schedule control)
- Perform action notification
- Support view, pan, and zoom functions
- Permit redlining and user comments for documents in process
- Control revisions
- Recognize and track the creation of multiple versions
- Use document metadata to facilitate locating documents
- Generate audit trails
- Analyze performance and create status updates
- Generate forms automatically
- Link to e-mail, URL's, on-line documents

A description of each attribute follows.

Support Existing Networks, Legacy Data, Personnel, and General Business Model

Implementation of electronic document management workflow represents either an enhancement (automation) of existing business processes or a reengineering effort to establish an improved process that can be automated. Selection of an EDMS that can operate effectively with existing computer networks and legacy information is desirable. Given the cultural constraints associated with EDMS implementation, it is best to replicate the workflow that users are accustomed to, unless the current workflow is in need of reengineering. Replicating existing workflows will minimize the "start-up" curve and facilitate the transition to electronic workflow. Unless the existing (prior to automation) workflow is flawed, the automated workflow should mirror the existing manual processes.

Recognize Pre-Defined Policies, Standards, Rules and Conditions and Incorporate Rules-Based Safeguards

Corporate policies and standards regarding file access, security, distribution of information, and general workflow can be defined within the EDMS system at the administrative level. Standards and policies promote acceptable workflows by all users of the system.

Rules-based workflows safeguard and prevent mismatched features, components or actions. By applying rules, decision-making efforts at the production level are reduced and tasks can be accomplished in a more effective manner.

Support Graphical Design and Portrayal of Workflow

The ability to define workflow pictorially is desirable. To use graphical workflow design features, icons or symbols representing the various steps of the workflow and associated resources are "dragged" to appropriate locations and linked as required. Typically these pictorial representations show the daily business processes associated with a project. Once the steps in the workflow are established, they are linked to qualify the desired workflow. Many users more readily understand the overall workflow when they view a pictorial representation.

Address Individual and Grouped Tasks

A task, once completed, occasionally breaks into parallel subsets of tasks that either lead to other individual completion goals or converge at a point along the workflow to re-establish the single path.

Determine Required Task Sequence and Identify Required Skill Sets Per Task

Task sequencing simply determines and establishes the logical sequence of steps to be completed so that desired goals can be achieved effectively. Each completed step in the workflow should have a "beneficiary" defining the next step (if any remain) in the workflow.

A workflow should determine the person(s) most suited (skilled) to complete a task and route the task to that person. The workflow application manages queues of pending documents to balance the workload of those personnel assigned to process incoming data.

Enforce Document Security Via Controlled Access

Document security prevents unauthorized modification of a particular document. Different levels of access privilege are predetermined, such as read-only, read - write, red-line, and comment. As a rule, only files relating to a particular user's task will be displayed for that user.

Automatically Route and Reroute Documents

The EDMS should monitor the status of a document and at the appropriate time either move the document to the next step in the workflow or reroute it for modification of content.

Control/Track Document Life Cycle

Document life cycle controls individual with appropriate privileges to monitor the progress of a document, and alter the workflow.

Launch Native Applications

The ability to launch native applications allows system users with write-access to documents stored in native format to modify a document within the EDMS environment. Clicking on the selected document will launch the appropriate application to open the document. In some cases, multiple applications could be used to manipulate documents in a particular file format. When multiple application programs could be used, users should be shown available applications and be given the ability to choose the one he or she wishes to use.

Adhere to a Calendar Schedule (Schedule Control)

EDMS workflow can facilitate schedule conformance by effectively assigning resources to tasks and making adjustments to resource assignments if a schedule conflict arises.

Perform Action Notification

Action notification is a feature that sends a reminder to a user in the workflow who has not responded to a task in his or her in-basket within the required time frame. Generally a time-per-task is defined. For a workflow to be effective, each document must proceed along the charted path within a predetermined schedule.

Support View, Pan, and Zoom Functions

An EDMS viewer should allow users visual access to all or a portion of a document. Ideally multiple pages of a document can be viewed simultaneously as well as different versions of a document.

Permit Redlining and User Comments for Documents In Process

Individuals responsible for particular tasks need a mechanism to share project-related ideas, concerns, and opinions at various stages in the workflow.

The ability to comment on or markup a document, to indicate suggested revisions is important for persons who have been delegated that particular responsibility (a person given the associated access rights assignment). Redlining overlays the document in question and does not alter the document itself. This function usually includes “sticky note” annotation for lengthy comments.

Control Revisions

When the requirements of a task are met, the existence of the new version should trigger the advance of the document to the next step in the workflow. The ability compare multiple versions of a document within a workflow is a desirable attribute of the EDMS.

Recognize and Track the Creation of Multiple Versions

If a document must at some point be routed to multiple users the system must assure that if the “truth” file is modified, all clones of that file also are modified to reflect the revisions.

Use Document Metadata to Facilitate Locating Documents

An EDMS needs to recognize and search on such metadata as account numbers, client names, project names, and other information that may be queried via a key word search.

Generate Audit Trails

Audit trails track the life history of a document through the workflow process. Each milestone in the life-cycle of a document is recorded and can be referenced if necessary.

Analyze Performance and Create Status Updates

Performance is measured by the efficiency of the resources associated with a project by gauging progress with schedule milestones. Potential bottlenecks are uncovered and, using a robust EDMS, resources are reassigned.

Project status can be extracted from the information available at each project milestone, allowing a user to generate a report reflecting current status.

Generate Forms Automatically

Templates and forms developed to address specific issues can be programmed to appear to users at appropriate places along the workflow.

Link to e-mail, URL's, On-line Documents

The ability to attach to a workflow all the vital components necessary for the efficient completion of a project is desirable. Workflow-related documents typically are not routed through a corporate e-mail system to a user's URL; however, notification of pending assignments in a user's "in-basket" is commonplace.

CADD-Specific Workflow Requirements

CADD workflow addresses many of the typical workflow processes as well as processes and tasks unique to the CADD environment. CADD files are much larger in size than standard business documents and require stricter management of repository resources. MicroStation reference files and AutoCAD XREF files associated with an accessed CADD file should be easily identifiable and displayed or downloaded with the selected drawing as well as the appropriate cell or symbology libraries.

Controlling access to documents as they pass through their life cycle is one of the most important components of automated workflow related to CADD drawings. Access control should be invoked automatically when a document status change occurs. As an example, when a document enters into a QC state or status, the document should be controlled to allow redlining of the document by those persons assigned to the QC functions, while ensuring others can not modify the file.

Metadata related to a document also may require access control features. In some instances, metadata related to a document should not be modifiable when the document status dictates that the document content itself may not be modified. Metadata should be definable on an individual status basis.

Automatic notification through corporate e-mail systems should occur based on status change. This feature should have the capability of configuration on a project basis because mail messages and routing information can change from project to project.

Document notes should be available to allow the user to define the reason for status change and also to define document content changes as they occur at any step in the document workflow. These notes should contain at a minimum the author's name, date and time, note type (i.e. general, status change, revision, system generated etc.), note subject, and note content. These notes should be saved in a separate table within the EDMS database and remain related to an individual document. Users should be able to search the notes database by content sub-string, date range, author, subject, and note type. Wildcard searches should be employed for each metadata member.

An accounting of each workflow step should occur. This accounting should automatically delineate such items as operation (i.e. new revision, status change, etc.), user, date and time, and workstation name. This accounting would not only audit existing workflow compliance but also provide a history that may be studied and used as a tool to optimize future workflow definitions for similar projects.

The life-cycle of a typical CADD file may be transitory or lengthy, depending on project requirements. A simple CADD drawing is created based on preset criteria, usually project related. A base or seed file containing the general parameters for the project is the source for each project-required CADD-generated file. As a rule, the electronic workflow for a CADD file will closely resemble the conventional (non-automated) workflow for the same document.

The Life-Cycle of a Typical CADD Drawing

Source data, either hard copy or electronic, provides the foundation for the drawing. This information can be comprised of sketches, dimensioned details, survey data (both electronic and "field book"), or large format drawings. The information is introduced into the CADD file as symbology or coordinate points, providing the base information on which design or as-built data is input. Finally, by either referencing the information to be digitized as background or by registering a hard copy of the information on a digitizing tablet, the CADD technician inputs the information into the file.

Upon completion of the electronic file a print or plot is generated. These prints or plots are then passed on to a QA/QC reviewer to be checked for accuracy, completeness and overall compliance with the project specifications. Desired modifications and redlines are noted and, if necessary, the prints or plots are returned to the CADD technician for revision. This step in the life cycle is repeated as many times as needed to produce a final CADD file.

Once the CADD file is revised, a second file plot is created for final review. If acceptable, the file is submitted for delivery to the customer and an archive copy is created. Back-up copies of electronic files preferably on-site and off-site must be maintained. Near on-line access to the on-site files makes the revision process or the addition of as-built data more efficient. Figure 13 depicts a typical CADD workflow.

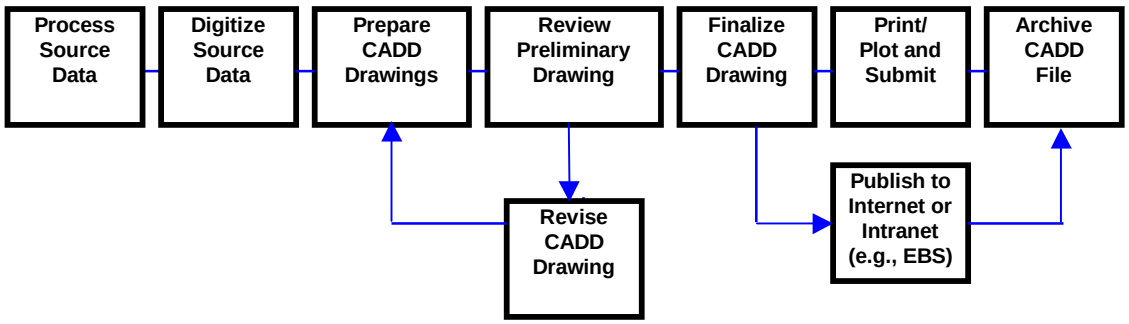


Figure 13. Typical CADD Workflow

More complex CADD design projects usually require more steps to produce required deliverables, and involve additional staff. Review by those accountable for the design detail as well as the confirmation of general information accuracy are two examples of critical steps in the production of the design file. Files may be maintained on-line or near on-line during the period that the client assesses the submitted project files.

The workflow path of an AM/FM/GIS file can be extremely complex. The process of constructing the file entails including additional peripherals such as database linkages, tables, and reference information. Preparation of complex CADD files requires full integration of spatial and attribute data.

Benefits of Automated CADD Workflow

Integration of CADD production tasks into an automated workflow results in a myriad of benefits that include:

- Productivity improvements as the workflow is streamlined
- Document access improvements for all project teams members
- Productivity improvements resulting from the decreased time required to locate drawings, facilitated by the use of metadata
- Productivity improvements from the ability to view files quickly prior to launching the associated native application
- Productivity improvements from automated document distribution and reproduction
- Analysis improvements from the ability to simultaneously view scanned legacy drawings alongside more current as-built information
- Quality and response time improvements since versioning control allows prompt response to change orders
- Quality and productivity improvements resulting from the EDMS preventing duplicate production efforts via the check-in/check-out process
- Security improvements since documents are secured from unauthorized access
- Project accounting and forecasting improvements from automatic generation of reports reflecting time spent on individual drawings, milestone progress, backlog, etc.
- Audit trail improvements that allow document access and state changes to be tracked to evaluate existing workflows and better define or streamline future workflows.

CADD Workflow Summary

Automated electronic workflows are used to move information through a series of steps and processes to reach an end result. The process becomes more complex when applied to CADD files. In a CADD environment, any particular drawing, such as a landbase, may need to be accessed by teams of technicians and designers to support a task assignment being carried out by others. The use of reference and seed files as well as multiple drawing layers makes version control a critical aspect of CADD workflow. As any file progresses through a workflow, all associated files must be identified and accessed. All the functionality required of EDMS workflow for business documents apply to CADD file management; however, CADD files are much more expansive documents with numerous interrelationships.

4 Current Use of EDMSs in DoD

Introduction

The Tri-Services CADD/GIS Technology Center elected to employ a user's survey, follow-up telephone interviews, and site visits as a means to gather the collective experience of EDMS users within DoD and the private sector. Within the DoD community, users have experience with multiple hardware and software configurations. These range from the JEDMICS (Joint Engineering Data Management and Control Systems), adopted as a standard for DoD storage and management of engineering data in 1991, to systems employing COTS (Commercial Off The Shelf) software.

EDMS User Survey

An EDMS User Survey was developed as a means of capturing lessons learned by EDMS users and soon to be users. A copy of the survey instrument appears in Appendix A.

EDMS User Survey Distribution List

The survey instrument was distributed directly to a number of known users; other potential users were sent a widely broadcast e-mail message announcing availability of the survey instrument on the Tri-Service CADD/GIS Technology Center Worldwide Web Site. Persons/organizations directly solicited for EDMS feedback are listed in Appendix A (see "EDMS Survey Distribution List").

[Note: The distribution list in Appendix A represents those persons contacted as of the dates specified. This list reflects the persons and organizations that were sent surveys. In some cases this list does not reflect recent changes in contact persons/organizations, since such changes occurred after the date of the survey distribution.]

EDMS User Survey Results

Of the 76 surveys distributed to personnel in the DoD and private sector, only five completed surveys were returned. A brief summary of these five responses, which are contained in Appendix B, follows:

Table 1
Summary of EDMS User Survey Responses

Organization	Contact Person	EDMS in use?	EDMS Planned?	Key Observations
Iowa National Guard HQ at Camp Dodge, IA	Dan Jave	No	Yes, but timing unknown	The current manual document management system will be ineffective as documents are made available to more users. A management system will be needed. CADD drawings are to be stored. Looking at placing documents on an Intranet also.
Navy PWC, Portsmouth (VA) Site Engineering Division	Jim Michonski	No	Yes, within 12 months	Concerns in moving forward are: 1) cost to implement, 2) system maintenance, and 3) proper storage format for compatibility with existing & proposed DoD standards. CADD drawings are to be stored.
USACE Jacksonville Dist. Engineering Dept.	Roger Porzig	Yes	---	Current user of Falcon/DMS. Has 115 system users with 35 concurrent. Primary function of EDMS is to manage CADD files, including legacy data. Not using electronic workflow. EDMS implementation hampered by LAN issues. EDMS payback was 12.5 months; it saves time searching for files.
Baltimore Gas & Electric, Gas Eng. and Construction Department	Larry Condry	Yes	---	Current user of File Magic Plus. Has 200 users with 20 concurrent. Acquired EDMS to supply most current record drawings to users in Districts. All drawings are scanned to produce TIFF files that populate EDMS, including legacy data. Current software not designed to capture CADD files. Internet & Intranet integration not being pursued.

Table 1
Summary of EDMS User Survey Responses (Cont.)

Organization	Contact Person	EDMS in use?	EDMS Planned?	Key Observations
U.S. Army Aberdeen Proving Ground, Directorate of Safety Health and Environment	Sterling "Bud" Keesee (New contact not the survey respondent)	Yes	---	The Environmental and Real Property Management System (ERPMS) has been implemented to manage all National Environmental Policy Act documents for the host and tenant activities. Document management and document approval and routing are accomplished using widely used COTS, principally Microsoft Access and Novell GroupWise. ERPMS serves 25 users, 5 concurrent. Web-based access is in the developmental stages.

U.S. Army Corps of Engineers, Jacksonville District

Additional information on the EDMS at the Corps of Engineers' Jacksonville District, beyond that collected via the survey tool, was obtained via a site visit and a review of a presentation by Mr. Roger Porzig entitled "Saving Money and Your Sanity." Mr. Porzig, the CADD Manager at USACE Jacksonville, stresses people issues when implementing an EDMS. He stresses that the EDMS must fit active systems and processes to have users embrace the new technology. User acceptance also depends upon how well users are informed of plans for an EDMS procurement and how well their concerns are heard and addressed. Mr. Porzig reports the following benefits of using an EDMS:

- Far less disk maintenance (85% reduction in time spent managing data on disk)
- Much faster access to complete data sets (now hours versus days)
- Improved information on usage patterns
- Improved productivity allowing more time to be spent on other issues

Interestingly, the payback period listed in the table above was based on a comparison of the cost of user search times before and after EDMS implementation to determine direct savings. Savings from reduced search times were compared with the cost of acquiring a functional EDMS system to yield a 12.5 month payback period. However, this conservative analysis ignores other savings, such as productivity-related cost savings from consistently working with the most current files. Consideration of such issues would decrease the payback period.

Aberdeen Proving Ground (MD) Environmental & Real Property Management System (ERPMS)

The completed survey and follow-up discussions during an on site meeting with Mr. Reed MacMillan, former Chief of Environmental Planning at Aberdeen, were used to capture information on ERPMS.

A five-year effort by the Directorate of Safety, Health and Environment at Aberdeen Proving Ground has resulted in a low cost but highly effective data management system. Based on COTS software packages including Microsoft Access, Word and Novell GroupWise, this system has enabled timely sharing of NEPA (National Environmental Policy Act) documents with the APG community. The NEPA process requires a multitude of reports and maps, ranging from environmental assessments and impact statements, which contain numerous maps, to special studies such as noise/AICUZ, cultural resources, threatened and endangered species studies, installation restoration documents, socioeconomic analysis and traffic studies. Finding appropriate information and avoiding duplicate studies requires efficient document management.

Novell GroupWise serves as the distribution tool, as well as the means of notifying users that a document's status has changed. If a document is modified by the recipient, a backup copy will be created on the recipient's machine. Hardware minimum standards were based on the criteria as defined by the Directorate of Information Management. However, many of the on-site PC's do not currently comply with these standards, thus rendering them incompatible with the system.

Using common COTS database, word processing and groupware packages to achieve EDMS functionality requires that all users have the same software versions and upgrade to higher versions at the same time. Upgrades to higher versions also can require some amount of reprogramming to retain compatibility and functionality.

The APG system effectively routes and tracks the NEPA documents from cradle to grave. This is important in that environmental issues directly affect many activities within federal agencies, including military installations. As shown on Figure 14, the APG intranet and LAN effectively enable the distribution of the documents to all interested parties within the Aberdeen Proving Ground site.

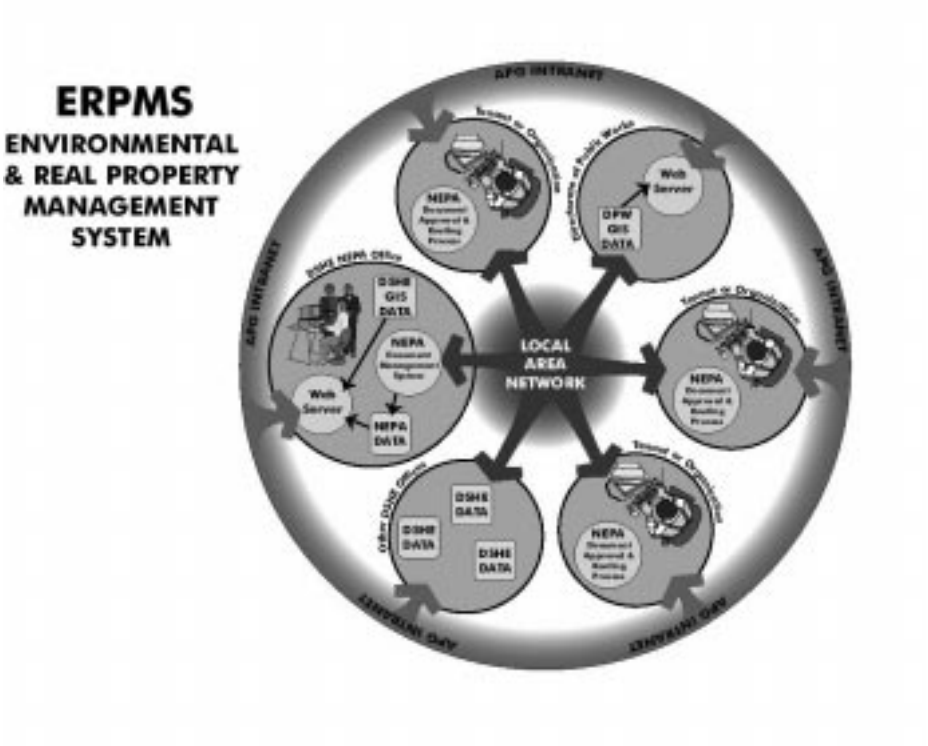


Figure 14. NEPA Document Workflow Within Aberdeen Proving Ground

The APG approach has been a very cost-effective means to implement EDMS on a day-to-day basis.

Certain system enhancements will be undertaken in the future. When upgraded and integrated with the on-base GIS, users will be able to select a location on a map and have the system identify environmentally-related documents for that site and its environs. For example, a user will be able to draw a one-mile radius and ask for all RECS within that area. The matches will be displayed on the map, and a list of the documents will be presented for review. Web access will provide an even more efficient mode of sharing the NEPA information with both the military and public sectors. A transition from the current Microsoft Access database to an Oracle database also is planned.

Information on other DoD and Federal Sector EDMS Users

To gather additional information on COTS EDMS software in use at DoD facilities, telephone calls, site visits, and World Wide Web searches were conducted. Information obtained in this manner is summarized below.

Naval Air Station Patuxent River (MD) Public Works Department

Initial information on the Electronic Document Manager at PAX River's Public Works Department (PWD) was derived from a National Technologies Associates, Inc. (NTA) web site "created for NAS Patuxent River Public Works, Contact: Bobby Bean (NTA, 1998)." The information obtained in this manner was

supplemented by a Patuxent River site visit with Mr. Bobby Bean and several personnel from NTA on 14 August 1998.

From the outset, Mr. Bean stressed that the PAX River Electronic Document Manager should not be viewed in isolation, the EDM is an integral part of a Shore Station Integrated Information System (SSIIS). SSIIS is a shore station enterprise-wide system. It integrates all steps in the typical life cycle of shore facilities, beginning with identification of facility requirements and progressing through planning, programming, budgeting, acquiring, inventorying, operating, maintaining, evaluating and disposing of assets. The SSIIS effort integrates four IT platforms: CADD, GIS, DBMS (both relational and flat file systems) and EDM.

A Resource Management Board has broad responsibility for improving and integrating information sources. Under the Resource Management Board is an Implementation Council responsible for the implementation and execution of the strategic plan for Business Information. The Implementation Council is supported by an Applications Council, Architecture Council and Data Council. Each Council is responsible for leading and developing strategies for life cycle management to support an integrated business process approach. These Councils also are to provide a migration approach that will allow PAX River to keep in step with technological advancements

The Electronic Data Manager (EDM) being developed for PAX River will be the primary vehicle for identifying and eliminating redundancy and facilitating information sharing. It links documents, people, culture and business processes to facilitate document sharing and spawn innovation.

As depicted on Figure 15, the PAX River EDM can/will manage a broad range of electronic file types, including GIS, CADD, World Wide Web, images, audio/video, and text. Metadata regarding these files feeds libraries and databases to permit knowledge mining. Use of metadata (called “associations” in EDM lingo) allows access to individual document components that are part of larger documents. In this manner, documents can be stored once versus numerous times, reducing data redundancy.

Developmental efforts on the EDM have been underway for approximately 18 months. An early pilot was conducted that involved loading Operations and Maintenance Manual hard-copy documents for approximately 1,200 facilities into electronic readable formats that allow for full text search capability. The Public Works Department has responsibility for all building, facility and project documents, which historically were housed in a paper-based Technical Library containing over 2,000 binders and folders. The operational and maintenance manual pilot scanning project involved 458 manuals scanned, which equates to about 350,000 pages, 70,100 files and 7.6 GB. As part of the data imaging and capture process, associations (metadata) were generated, including data on building numbers, model/serial numbers, schematic/drawing numbers, equipment inventory codes, and contract item line codes.

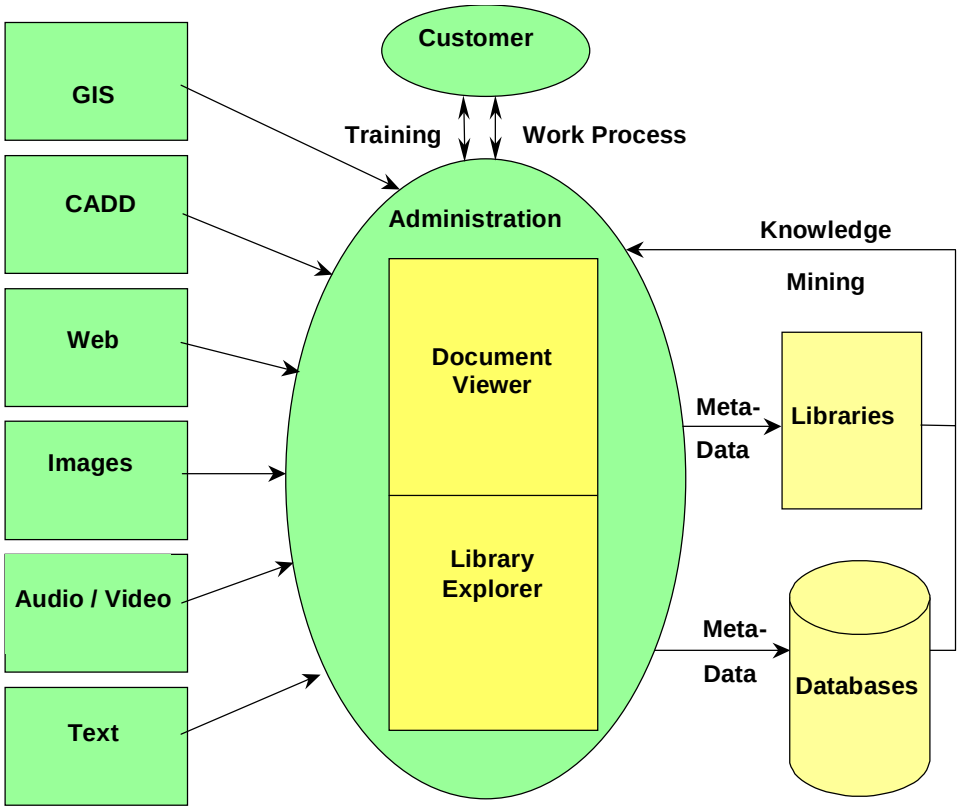


Figure 15. Electronic Document Manager Process at Patuxent River NAS

The PAX River EDM incorporates the following six functions:

- System Administration: This is the central launch point from any client. System upgrades are accomplished at the server level, giving users immediate access to the software updates upon network log-in.
- Library Explorer: The library function controls check-out and check-in, and assigns document manipulation rights (modify vs. read-only) depending upon which user signed out a document first.
- Document Viewer: Some documents are assembled using a number of different file and image types. EDM supports a large number of electronic formats and is able to launch appropriate commercial-off-the-shelf viewers for the many data types encountered as one moves through a document.
- Team: The Team function is the communications tool for collaborative work, ranging from broadly distributed new flashes to a chat system, video teleconferencing and peer communications.
- Data Mining: This function uses associations (metadata) for enhanced search capabilities to quickly find needed data.
- Training: Traditional classroom training is employed: however, Just-in-Time (JIT), Computer-Based Training (CBT) is being implemented, allowing users to tailor their learning pace to their abilities, needs and time constraints. This electronic means of training is being tailored to the daily business processes and workflow.

At this time, there are approximately 296 users who have access to the EDM functions. About 82% of these users come from Public Works (which includes the environmental functions at PAX River) and the remaining users are dispersed throughout the Shore Station. At PAX River, the EDM not only supports traditional facility management functions, but is proving useful in the National Environmental Policy Act (NEPA) planning process. Likewise, the EDM is helping to clearly define contractual requirements and limits for outsourced custodial services.

Upon completion of the ongoing software development, the Electronic Document Manager will have functionality of particular interest to engineering and facility managers. These functions include: improved CADD document viewing for AutoCAD, MicroStation, and ArcView images; image hotspots that support zoom functions; workflow via a flexible workflow builder; sticky note features to support team commenting; team messaging, including broad distribution messaging ("news flashes"); a chat system; private communications between two parties; and Computer Based Training tailored to permit progression from a novice to expert user. In the near future, the EDM will be made "smart." This means that it will interact with the DBMS and be able to initiate actions on its own, based on certain business rules. For example, once fully developed, the EDM will be able to follow rules governing document retention. Based on these rules, the EDM will delete or archive files as appropriate, without user intervention.

Tinker Air Force Base (OK) Air Logistics Center

Throughout the DoD, budget cuts have fostered initiatives to extend the service lives of weapons and associated delivery systems. Service life extension activities to date have shown that over time, replacement parts availability issues and parts obsolescence become obstacles to readiness. The magnitude of the replacement and obsolete parts problem will increase as longer service life extensions are mandated. At some point, parts needed to keep critical systems operational have, or will, become unavailable from the traditional suppliers. Recognizing the need to improve procurement systems to align with evolving service life requirements, a joint effort has been undertaken by the Army Communications Electronics Command (CECOM) and Oklahoma City – Air Logistics Center (OC – ALC) to establish a Virtual Enterprise and Integrated Data Enterprise.

Discussions with Mr. Edwin W. Kincaid, the Information Technology Manager at Tinker Air Force Base, Oklahoma, and a review of materials he furnished for the research effort, revealed a data management approach of potential interest to the readers of this report. He reported that the Air Logistics Center in Oklahoma City has piloted a Product Data Management (PDM) system that supports the parts procurement process, including the need to reverse engineer unavailable or obsolete parts. Although this PDM offers some features typically not required by facility engineers and managers, particularly the ability to generate solid models and associated production engineering drawings, it is described here because the Tinker AFB PDM incorporates many desirable EDMS features.

COTS software was chosen for the PDM backbone of the Rapid Response to Critical System Requirements (R2CSR) system. The Air Force elected to use a

COTS approach because of cost considerations and its need to stay current with industry technology standards used by its suppliers. The particular PDM software in use at Tinker AFB was acquired from Metaphase Technology, a division of Structural Dynamics Research Corporation (SDRC). Product data managed by this system includes information pertaining to:

- Design
- Analysis
- Manufacturing
- Logistics
- Contracting

Numerous file types can be viewed and manipulated within Tinker's PDM system. Commonly used raster and vector graphic images are viewable, as are text-based documents associated with product design, development, and manufacturing processes. These electronic files are routed to many persons in a virtual enterprise via a built-in workflow feature. Mark-up capabilities allow all comments pertaining to the drawings or documents to be assembled, reviewed, and integrated. The PDM offers a full range of benefits typically associated with an EDMS, including audit trail retrieval, standardization of data, security, and reduction or elimination of many time-consuming data or drawing retrieval processes. Additionally, the ability to interact with existing data management systems such as JEDMICS streamlines the data-sharing process.

An ability to create highly detailed digital models of components eliminates the time that used to be spent altering physical prototypes of component parts. Using the 3D modeling tools within the PDM, component features, such as dimensions, surface finish, and geometry can be manipulated until the optimal design is achieved for a product. All parties involved in designing, manufacturing, and procuring a component, including the potential suppliers in a virtual enterprise environment, are able to review and comment on the component prior to the actual tooling and manufacturing process.

Tinker AFB has hired a vendor to develop improved imaging software that will enhance the cleanup of electronic images, improve the ability to locate text information on drawings, use OCR to capture data and identify text data content. This improvement to the imaging process will automate the metadata capture process and facilitate future document retrieval efforts (KM World, 1998).

As the R2CSR system matures, it will be offered as a global solution within other DoD organizations. Enterprise-wide file maintenance and query capabilities, a common architecture designed to replace inefficient file storage systems, and cradle-to-grave data management will bring a new level of efficiency to the design, production and procurement of weapons systems components.

Although certain PDM functions may be of limited value to facility engineering and management personnel, a good PDM can provide EDMS functionality. Therefore, some persons or organizations may wish to adopt a PDM, which would bring with it certain engineering/modeling capabilities of potential value, to accomplish common EDMS functions.

Joint Engineering Data Management Information and Control System (JEDMICS) (EDMS Program Management Office at Redstone Arsenal, 1997)

JEDMICS is a repository system for managing and controlling engineering data, namely legacy data stored in hard copy or legacy computer systems. This system has been developed specifically for DoD by PRC, Inc. However, JEDMICS integrates commercial-off-the-shelf hardware and software. It is a standard DoD program for managing approved engineering drawings and related digital technical data in the Army, Navy, Air Force, and DLA. As a repository system, data is input to JEDMICS primarily by scanning drawings, aperture cards, and documents, with lesser reliance on input of CADD files in a native format. The JEDMICS repository contains 55,400,000 images of engineering drawings (55% are Navy, 17 % are Air Force, 17% are Army, and 11% are DLA).

Information on JEDMICS is included here to demonstrate that for some applications, the ability to handle large numbers of released documents in a repository is paramount. It also is included to show that many components of an EDMS, even a custom system like JEDMICS, can incorporate much COTS hardware/software, notably scanning, storage, access, and printing/plotting devices. Since repository systems do not address the specific needs of users who manage files while in process, JEDMICS is not discussed further in this report.

Corps of Engineers Electronic Record-Keeping Information System (CEERIS)

Since it's inception in 1996, the internally-developed Corps of Engineers Electronic Record-Keeping Information System (CEERIS) has provided various COE sites with the ability to effectively manage, store, retrieve and share various documents used within the COE on a daily basis (Document Management & Imaging Systems, Inc., Undated). Prior to installing CEERIS, documents had been maintained as microfiche and paper hard copy. Types of documents include typical office documents, scanned images and CADD files.

The St. Paul, Minnesota and Philadelphia COE offices use CEERIS to process and manage permit applications for construction along coastlines and inland waterways (OTG Software, 1998). The St. Paul office uses CEERIS to scan, store, retrieve, and manage permit applications. Materials contained in permit applications includes text, photographs, CADD drawings and sketches. Permit applications and issued permits electronically enabled by the St. Paul District can be accessed by any COE office via the WAN. Current CEERIS users include St. Paul, Philadelphia, Tulsa and Wilmington Districts. As more sites come on-line with CEERIS the data-sharing base will be broadened to include real estate, engineering and environmental restoration information.

Oak Ridge Centers for Manufacturing Technology, Oak Ridge, Tennessee

Information on the government owned DOE-Oak Ridge Electronic Document Management System was obtained from its web site and a follow-up discussion with Ms. Connie H. Malarkey, a section head in the IT group (Oak Ridge Centers for Manufacturing Technology, 1997).

Oak Ridge has had an EDMS in use since 1987. Thus far it is used to manage 22,000 documents in text and CADD format, plus two million scanned medical records. At the time this EDMS was developed, there were no commercial systems with appropriate functionality and robustness. EDMS software development was accomplished by Lockheed Martin Energy Systems. The current system employs a VAX VMS repository. The DOE EDMS is not commercially available and its VAX environment inhibits commercialization. Core functions within the system manage the central repository for document storage, manage document workflow and provide configuration control, provide index and keyword storage, provide queries for search and retrieval, control access, manage transmittal and distribution requirements, and log document access.

A migration to PCs versus VAX workstations is underway. A current initiative at Oak Ridge is the transition to CADD/Modeling software that will work with PCs. However, the software selected for this purpose does not have versioning control and will need to be used with an EDMS to capture information to allow revisions and send files to a workflow environment. Likewise, Oak Ridge is working on a 3-D CADD application for PCs, but it too will need to be linked to a companion EDMS.

Ms. Malarkey is encouraged that commercial EDMS software has gained robustness and functionality that may allow DOE to incorporate COTS as it migrates to a client-server environment.

DoD Use of EDMSs

EDMS technology is in its infancy, but improving daily. Many DoD organizations and activities use repository functions via JEDMICS, but only a hand full of DoD activities use EDMSs for management of engineering documents while in-process. Although the preceding pages furnish information on EDMS use at some progressive activities, wide-spread EDMS use for in-process engineering applications is limited. However, faced with downsizing and budget reductions, organizations are investigating EDMS technologies to automate and share corporate information and knowledge.

Various components of the DoD use both government owned and commercially available EDM systems. EDMS needs and expectations are unique to a particular organization's mission. In some cases, the EDMS serves a useful function as an electronic repository for final or released documents and guidelines. Use of EDMS to manage a large repository of information often yields tremendous benefits to organizations that have little need to manage work-in-progress. A repository is valuable to organizations wishing to furnish diagrams, guidance documents, reference materials, parts lists, and related documents in a released state to many personnel located in the field. In such applications, an organization's ability to

easily populate a repository, typically via a high speed scanning and indexing process, is of primary importance. Likewise, the ability of end-users to readily access information from a large repository, aided by the EDMS, is critical.

Organizations wanting to improve the creation of document sets while work is in process, have a different set of needs. Such organizations, when using EDMS for engineering and facility manage documents, have a need for

- Strong versioning and revision tracking and controls
- A flexible workflow that is adaptable to document or project-specific changes "on-the-fly"
- Scanning and plotting capabilities to handle large-scale drawings/plan sheets
- An EDMS that directly links to desired native CADD environments so that appropriate documents versus images of the actual documents can be used to redline or draw modifications.

The key element in determining whether an image-based EDMS, essentially a modern version of microfiche image distribution, is suited to an application is the anticipated completion state of documents to be indexed in the EDMS. If an organization elects to use the EDMS to disseminate current final or released documents to many users and help those users locate pertinent files, an image-based solution can be very effective. However, if the EDMS will manage the iterative workflow common in an engineering environment, requiring access to files in their native CADD environments, the system requirements change. In other words, prospective EDMSs must recognize that management of documents in a released state differs considerably from managing documents that are in process.

Looking at the bigger picture, management of both released state and in process documents requires a similar bundling of networked computer components. These components are available to DoD organizations via the CAD-2 program. Both Intergraph Corporation and Cordant (Tracor), the two CAD-2 vendors, offer vendor hardware and software that can be used to build an effective EDMS (Intergraph Corporation, 1997 and Cordant, 1997). Both organizations can furnish

- Engineering workstations and servers
- Mapping and image analysis workstations
- Software, including EDMS, facilities management, CADD, and GIS
- Networking components and
- Input, storage, and output devices.

These organizations also can furnish software engineering; systems engineering, integration and networking, installation, training, and support services.

Concurrent EDMS Guidance Efforts

Users of this report may wish to track two other DoD projects that will generate additional EDMS guidance. These efforts, described below, have been undertaken by Headquarters, Naval Facilities, Engineering Command (HQ NAVFAC) and the U.S. Army Corps of Engineers (USACE).

HQ NAVFAC

NAVFAC formed a task team in early 1998 to look at methods of improving the current document management practices throughout the command. One of the items the team is currently working on is the study of Electronic Document Management Systems. For the past few months, the task team has been collecting information on various systems, visiting trade shows, and studying an EDMS system NAVFAC currently has in place at one field activity. From all of the information collected, the team has put together a list of criteria for evaluating EDMSs. The NAVFAC criteria list, furnished courtesy of Ms. Louise McMonegal of NAVFAC HQ, is contained in Appendix C. The team is currently using this criteria list for the evaluation of systems. During the last quarter of 1998, the team will report on its findings, which will be submitted to the NAVFAC CIO office.

USACE

A FY99 EDMS initiative has been funded at HQ USACE. All information on this initiative was supplied by Ms. Jean McGinn. USACE is identifying its common technical and functional business requirements for all Districts using a task group forum. The task group is addressing engineering functional and technical requirements for an EDMS, and is concurrently performing a survey at two USACE Districts, Baltimore and Huntington (WVa) to determine the functional and technical requirements for all other functional areas within a district which interface with engineering during the programming, design, and construction phases of a project.

All facets of document management are being addressed, and have been broken into four major requirement categories:

- A core management environment featuring rules-based routing, document annotation and distribution
- A flexible environment that allows system customization to meet specific requirements
- A centralized repository environment that includes access control
- A platform and document management infrastructure capable of being accessed across the heterogeneous infrastructure of the enterprise

All traits typically associated with an EDMS are being considered, including document capture, document management, document storage, document retrieval,

document exchange, document output, DMS library functionality, system management/administration, user management/administration, workflow and recordkeeping.

Standards for operating systems, software, hardware and file formats are being outlined under the HQ Initiative. Compatibility with existing COE systems such as CEERIS will be required, and the DMS servers must be capable of supporting various network environments including TCP/IP, ISDN, FTP, SNMP, etc. Interoperability with existing DoD electronic mail/messaging systems will also be required, as defined by the DoD Defense Information System Network (DISN) standards and procedures.

The EDMS shall be web-enabled and support the total functionality of a web-based extranet and be compatible with current Internet/Intranet industry standards.

5 Implementation Issues for DoD

Common EDMS Implementation Issues

As stated in Section 4, EDMSs, regardless of the using organization, are designed to handle either released state documents or in-process documents as well. Either approach can be successful, depending upon the user's intent and application. Once a using organization, whether DoD or not, analyzes its EDMS needs and settles on EDMS and workflow requirements, an EDMS vendor will need to be selected.

Successful implementation of an EDMS requires use of an incremental approach. Those involved in system design need to

- Solve simple, bounded, and measurable problems first (see Figure 14)
- Identify processes that can be easily bounded and allow for an easily measurable return on investment

Examples of bounded processes include

- CADD engineering document management
- Document control, storage, and reproduction
- Project management, reporting, and communications
- Product design review and document sign-off
- Vendor management and communications
- Engineering change order process (ECN/ECO)

Figure 16 delineates the boundaries of a paper bound process. Each process can be studied individually to determine the EDMS requirements that are specific to the given process. EDMS techniques should then be applied to those specific requirements to effectively provide a document management solution. In practice, the EDMS is a collection of many bounded processes, as depicted by Figure 17.

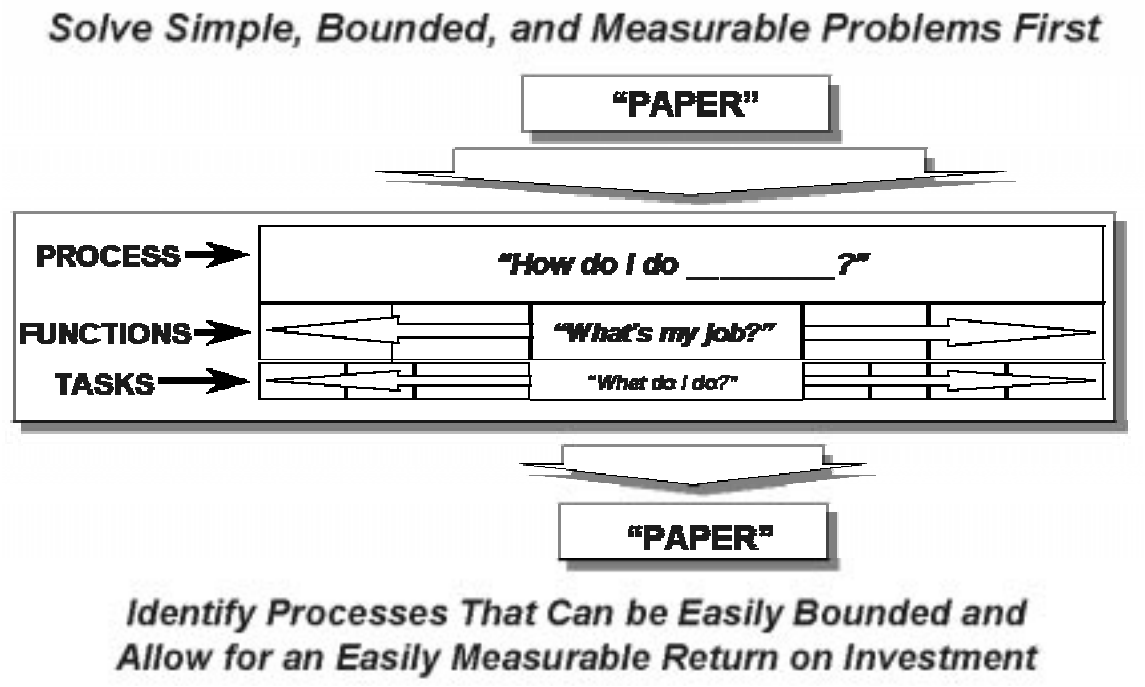


Figure 16. Paper in - Paper out Approach to defining EDMS process

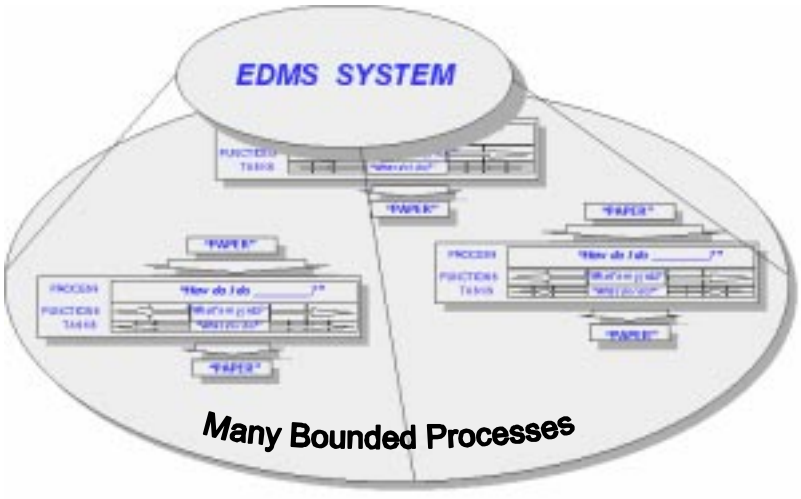


Figure 17. Full EDMS is a collection of individual processes

EDMS Phased Approach

As with any major technology project, the potential for process enhancements must be balanced against the need to avoid disruption to existing processes. Thus, a phased implementation of new technologies is recommended. Each phase paves the way for movement to the next technology level and lessens the user's exposure to risk while allowing enough time to organizationally digest each innovation as it is implemented.

Design documents are valuable assets that impact nearly all engineering and facilities management processes. Therefore, whenever new technology is incorporated into a critical process, such as the management and distribution of design data, the technology must be thoroughly evaluated before being implemented on an organization-wide basis. Typically, this evaluation should begin with a pilot program that consists of the following tasks:

- Developing an implementation plan and set of critical success factors for the pilot
- Mapping out the data requirements to develop technology specifications and configurations
- Acquiring and installing required technology to conduct the pilot phase.
- Developing pilot procedures
- Validating the pilot
- Developing a long-term plan for implementing a production capable EDMS
- Expansion plan delineating growth or upgrade potential

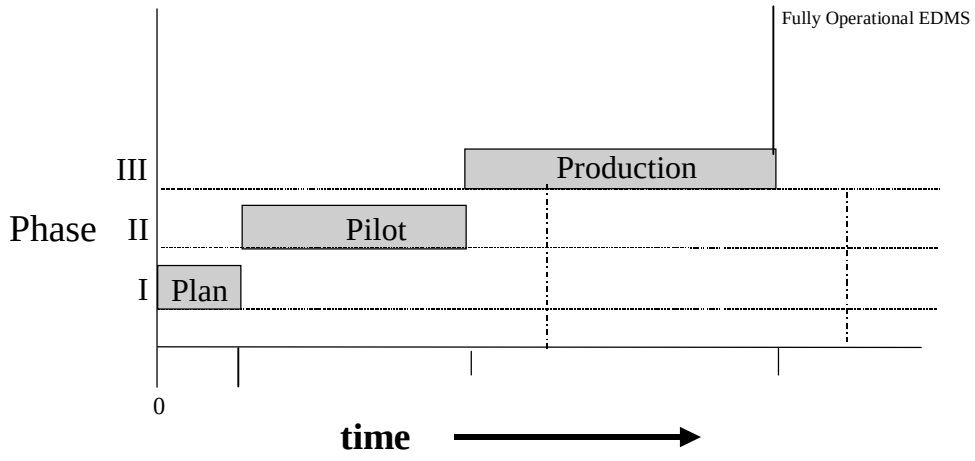
Experience shows that a three-phase approach for implementing the EDMS has the best chance for success. These three phases are

1. A "**Planning**" phase. A structured analysis of the customer's integration requirements on a business and technology level

2. A "**Pilot**" phase. A prototype implementation and demonstration of the technology to be used allowing the user to model, measure, adjust, and improve the implementation, integration, and capabilities of the technology

3. A "**Production**" phase. A full scale implementation of the piloted technology adapted to meet the requirements of a production capable system

The timeline below represents the relative execution of an overall EDMS project. The amount of time for each phase, as shown on the horizontal axis is different for each process that is enabled with EDMS technologies.



This phased approach has been developed to validate the required technology and integration services. To deliver a complete system a portion of the EDMS implementation is the integration of the varied system components into the user's environment. The suggested three-phase approach facilitates identifying and fine-tuning the integration effort required for a successful EDMS implementation. Each phase should be structured within the context of the user's unique business needs and in support of the following implementation goals:

- Minimizing the cost and time required to implement the pilot
- Minimizing disruptions to ongoing operations
- Minimizing the user's staffing requirements for implementing the pilot
- Minimizing risk when transitioning to the full production scale EDMS system

Each phase of an overall EDMS implementation strategy is described below. A cost range for each of the three listed phases is listed. These ranges reflect the direct experience of the project team and do not include any special customization that may be required by a user, based on unique requirements. These estimates also do not include the travel and living expenses that would be incurred during the consulting and installation efforts.

I. Planning Phase ($5,000 to $15,000)

The primary objective of this phase is to develop an in-depth understanding of the user's EDMS requirements and to specify an appropriate implementation strategy. The goal is to create a program plan that utilizes products and systems to be used in the pilot phase. Therefore, the systems and products specified for the pilot should satisfy a subset of the requirements for the final production EDMS. Only additions to and adaptations of the systems and products tested in the pilot phase should be

required, to meet the "real world" requirements of a production-ready EDMS. The planning phase should deliver a first cut plan for bringing a production scale system on line.

Major tasks associated with the planning phase are as follows:

- Perform a detailed assessment of the data requirements (i.e. storage, backup, archival), operating environment, technical specifications, and affected processes and procedures associated with the implementation of an EDMS.
- Establish the database configuration and the minimal data set required for the pilot as defined by the types and number of documents.
- Establish hardware and software specifications required to support the pilot, recognizing the requirements of the full production system.
- Develop an implementation plan that defines the tasks, responsibilities, and level of effort required for the pilot phase, using the pilot to define more fully the production scale EDMS.
- Develop an acceptance criterion for the pilot as a trigger to advance to full scale implementation. This criterion is in the form of success factors (metrics) for the pilot.

Those persons wishing to obtain additional information on EDMS requirements are directed to Appendix C. It contains criteria the Naval Facilities Engineering Command has set forth, criteria that should be considered when planning an EDMS, and defines them. The Technology Evaluation Criteria Definition Worksheet in Appendix C was furnished by Ms. M. Louise McMonegal of Headquarters, Naval Facilities Engineering Command.

II. Pilot Phase ($10,000 to $20,000)

The primary objective of this phase is to demonstrate the "proof of concept" for the EDMS and to validate the technology that will eventually become a production-ready EDMS. To minimize expenditures, technology acquired for this phase is based on the requirements of the pilot and is scaleable to the full production scale EDMS to preserve the customer’s investment in hardware and software.

This phase can be considered complete when the pilot program satisfies the predetermined acceptance criteria and a strategy for transitioning to a production-ready EDMS has been finalized. This phase provides the foundation for the implementation of a production-ready EDMS.

The major tasks associated with the pilot phase are as follows:

- Install EDMS as detailed in the pilot EDMS implementation plan and the user’s statement of requirements.
- Based on the pilot data model, coordinate and capture the specified pilot documents.

- Store and index the pilot documents within the EDMS.
- Validate the pilot in accordance with the predefined acceptance criterion.
- Establish production-ready EDMS integration/customization requirements.
- Develop an implementation plan that defines the tasks, responsibilities, and level of effort for the production-ready EDMS.
- Develop the acceptance criterion for the production-ready EDMS.
- Establish hardware/software requirements to support the production-ready EDMS.
- Establish the production database configuration.
- Define and document the procedures, training, and organizational responsibilities required to train for, administer, and effectively use the production-ready EDMS.

III. Production Phase (cost depends on number of users and implementation sites, but could range from $400 to $1,200 per user [non-concurrent])

The primary objective of this phase is to deliver a production-ready EDMS that meets the user's needs and expectations. This phase also includes all required systems integration to fully incorporate the EDMS into the user's overall environment.

Given the logical sequencing of phases, with an inherent emphasis on planning, the production system should perform as desired and immediately begin to contribute to improved productivity.

The major tasks of the production phase are as follows:

- Based on the production data model, coordinate and capture the remaining legacy documents.
- Store and index the remaining legacy documents within the EDMS.
- Integrate the EDMS with existing systems and applications
- Validate the production-ready EDMS in accordance with the pre-defined production acceptance criterion.

Sample Acceptance Plan

An incremental approach to EDMS implementation is recommended; it facilitates getting an EDMS in place that satisfies user needs. At certain milestones in an EDMS acquisition process users ultimately must determine if they can or should accept the EDMS. Many organizations establish a formal acceptance plan encompassing a number of pass/fail criteria. To the extent that such criteria are known before a vendor is selected, organizations often share these criteria with potential vendors during the procurement process.

To assure that all functionality is working properly, the EDMS should be tested by an independent test group against the acceptance plan. This testing by the test group should begin after the installation of the pilot and continue into the production

phase.

It is recommended that there be an informal and formal testing procedure. During the installation of the EDMS, informal testing should occur prior to the final system verification. The purpose of the informal testing is to locate and remove problems before the system is formally tested. Formal testing is defined within the adopted acceptance plan.

The following criteria are part of a sample acceptance plan. Each individual organization needs to adopt an acceptance plan that is tailored to its particular needs. An acceptance plan for an EDMS used to manage in-process CADD files should include any or all of the following criteria:

1. Login

	Pass	Fail	
1.1	❑	❑	Login menu displays when EDMS is initialized.
1.2	❑	❑	User can login to the EDMS.
1.3	❑	❑	Error message is displayed when an invalid login/password combination is input.
1.4	❑	❑	User can exit the login menu.
1.5	❑	❑	User menu is displayed when EDMS is initialized for user.
1.6	❑	❑	After logging in to the system as one username, user can exit to the login menu and login again using a different login/password.

2. Check Out

	Pass	Fail	
2.1	❑	❑	Can a user check out one file?
2.2	❑	❑	Can a user check out multiple files selected from the list of items?
2.3	❑	❑	Error message appears if attempting to check out an item that is currently checked out.
2.4	❑	❑	Check out a single MicroStation design file. Verify that the related reference files automatically are brought down to the client as read-only files. Verify that the design file is brought down to the correct location.
2.5	❑	❑	User menu is displayed when EDMS is initialized for user.
2.6	❑	❑	After logging into the system as one username, the user should be able to exit to the login menu and login again using a different login/password

3. Check In

	Pass	Fail	
3.1	❑	❑	Can a user check in one file?
3.2	❑	❑	New file revision and version created on successful check in.
3.3	❑	❑	Error message appears if user attempts to check in an item that is checked out to another user.
3.4	❑	❑	After checking out an item, replace the checked out file with another file by naming the new file the same as the checked out file. Then check in the item.

4. Create File

	Pass	Fail	
4.1	❑	❑	Create file generates next available file number when the discipline is selected.
4.2	❑	❑	Create file requires user to input revision number, description, and title block information
4.3	❑	❑	Create file allows user to input all keyword fields.
4.4	❑	❑	When creating a MicroStation design file, a seed file can be selected.
4.5	❑	❑	When creating a MicroStation design file, all of the title block information that has been entered into the database fields is automatically placed in the design file at the locations defined by the seed file definition.
4.6	❑	❑	The MicroStation application is automatically invoked by the EDMS when the newly created file is checked out.

5. Search

	Pass	Fail	
5.1	❑	❑	EDM software can search on all criteria.
5.2	❑	❑	EDM able to search on file number only.
5.3	❑	❑	EDM able to search on revision number only.
5.4	❑	❑	EDM able to search on drawing number only.
5.5	❑	❑	EDM able to search on drawing title only.
5.6	❑	❑	EDM able to search on originator only.
5.7	❑	❑	EDM able to search on unit number only.
5.7	❑	❑	Clear Search function clears all criteria fields.

These are sample acceptance criteria only. Additional testing sections and criteria need to be added to fully address a particular user's requirements.

Selecting A Vendor To Implement an EDMS

A complete set of EDMS requirements and expectations as well as a thorough inventory and understanding of existing computer systems and data serve as the starting point for selecting an appropriate vendor. Such background knowledge is especially useful should procurement guidelines require a formal competitive

bidding process. With EDM systems, considerable variability exists in the capabilities of commercially available systems, primarily due to differences in intended applications. A well-defined, results-oriented approach limits the number of vendors that offer appropriate solutions.

Following are guidelines for selecting a vendor. These guidelines are a synthesis of suggested guidelines from a number of vendors and the project team.

1. Choose a vendor that has solved problems similar to your own. For instance, if you are managing large-scale documents or in-process files, avoid vendors familiar with managing only small-scale, released business documents.

2. Select a vendor that will take the time to understand your current computer systems, documents, and workflow processes and consider these when customizing your EDMS.

3. Avoid vendors that offer products from only one or a few parties. Partnerships with a large number of software and hardware suppliers are desirable, because the best pieces, regardless of supplier, can be assembled to yield a highly effective EDMS.

4. Ensure that the selected vendor and software can support expanding the scale of the EDMS. Although an EDMS may be applied to a limited number of bounded processes when implemented initially, over time it likely will be tasked with managing additional processes for more users.

5. Seek out references from organizations with similar functions and similar expectations of an EDMS. Many vendors offer valuable information on their World Wide Web sites; however, information from users should be obtained directly.

6. Be open to a potential vendor's suggestions. For instance, should a vendor suggest two different EDM systems, one for small-scale and one for large-scale in-process documents, evaluate that suggestion. Then decide what system is best for your organization. Dismissal of new ideas, without adequate analysis, may prevent optimal solutions from being employed.

6 Lessons Learned

Section 4 presents the EDMS user survey responses and highlights of other data collection efforts: World Wide Web searches, telephone interviews, review of presentation materials and site visits. These sources have been used to compile the following list of lessons learned.

U.S. Army Corps of Engineers, Jacksonville District

The following lessons learned are those of the U.S. Army Corps of Engineers, Jacksonville District. This organization has an operational, COTS, EDMS that is used in an engineering environment. Lessons learned by that organization are particularly revealing for prospective engineering and facility management users wishing to implement a COTS EDMS.

- Do not underestimate the people issues involved in implementing an EDMS. An EDMS must integrate with existing systems and processes to have users embrace and use the new technology, rather than find ways around the EDMS.

- User acceptance also depends upon how well users are informed of and participate in the EDMS procurement process and how well their concerns are heard and addressed.

- The EDMS must deliver the desired functionality. For those persons involved in engineering design or facility management, an EDMS must incorporate

    - Strong versioning and revision tracking and controls
    - A flexible workflow that is adaptable to document- or project-specific changes at any time
    - Scanning and plotting capabilities to handle large-scale drawings/plan sheets
    - Seamless links to native CADD environments so that appropriate documents versus scanned images of the actual documents, can be used to redline or draw modifications

- Since a newly acquired EDMS must integrate with existing information technology systems employed in the organization, weaknesses in those systems likely will manifest themselves. In the case of the USACE, Jacksonville District, installation of the EDMS surfaced problems with the local area network.

- To foster success, a phased implementation approach must be employed.

Patuxent River Naval Air Station (PAX)

The approach at Patuxent River has been different from that at the Jacksonville COE. At PAX, a software development firm is being used to develop an EDM that integrates with the Shore Station Integrated Information System to achieve a totally integrated approach to business information management. Although the software developers are using mostly COTS software products that are considered shareware (such as image viewers), the overall Electronic Data Manager is a Government-owned piece of software. The EDM has undergone development and customization that allows it to be tailored to support the Navy and DoD business. It also is adaptable to other DoD installations. Interestingly, the lessons learned via this approach have many similarities to those at the Jacksonville District site. Primary lessons learned, as reported by Mr. Bobby Bean and the software development team, are summarized below.

- Recognize that people issues, in the form of EDM acceptance and use, are at least as important as the technical/technological issues. Although users of the EDM can be tracked electronically, and non-users identified, user acceptance, versus policing efforts, is the key to success. User acceptance is achieved only when a user recognizes that the EDM will help him or her perform better through easier access to the right information. For wide-spread user acceptance, the EDM must add value to the users.

- Consider how a planned EDMS will fit in with existing systems and take a long-range, strategic view of how an EDMS will improve your business. Existing business information need not be transferred to the EDMS, provided it is connected (networked) to the EDM platform.

- Measure the value of an EDMS in terms of either an improved return on investment or improved customer (end-user) satisfaction. Early in the implementation cycle, it is much easier to measure customer satisfaction. For example, the PAX Technical Library provides all the instructions and legal requirements that drive the Navy's approach to installation management. Using web technology, much of the information needed to support installation management exists on a web server. Making documents accessible via the web reduces storage requirements and provides users ready access to current information, yielding improved customer satisfaction.

- Choose or develop a software package that is adaptable to your business process. Do not allow the software to dictate changes to the accepted business processes. Set cabinet and folder structures so that these can be named to support the DoD business conventions.

- Maximize your organization's IT investment by configuring "smart systems" capable of applying business rules without manual intervention. For example, automated date stamping of documents, combined with business rules governing document retention, allow the EDMS to notify a user when documents can be archived. Build the smart systems support functions around the life-cycle management concept and the Tri-Service Standards products.

- Supplement traditional classroom training and paper-based training manuals with creative, innovative, interesting computer-based training. Integrate self-testing capabilities and an ability to choose training levels suited to a particular user's level of expertise. Interactive computer-based training facilitates learning by allowing users to hear, see and do, appealing to all learning styles

- Cooperate or partner with the selected EDM supplier or developer, working together as an integrated team with shared goals and objectives.

- Consider systems administration implications of the EDMS. Systems administration is eased if the EDMS software resides on the server, allowing automatic updates for every user at the time of network log-on.

Tinker Air Force Base, Oklahoma

Tinker Air Force Base is using product data management software to improve the acquisition of repair parts for aircraft. Service life extensions for key aircraft types range from about ten years to nearly 50 years. In many cases parts must be obtained from new sources, requiring the electronic transfer of models to potential suppliers or reverse engineering when parts are unavailable to model. The PDM supports a true integrated data environment that supports a virtual enterprise. Lessons learned thus far are:

- The management software must automate the capture of metadata for both engineering drawings and associated documents.

- A multitude of documents relate to a specific part (or facility). The document manager needs to focus on the part (or facility) versus documents. At Tinker, this is defined as a part-centric versus document-centric focus.

- For virtual enterprise applications, the document manager needs to be a pervasive infrastructure rather than a repository or vault.

- Collaboration in a virtual enterprise requires access to all information, versus only released documents. At Tinker AFB, the PDM allows collaboration within the Air Force and its supplier network, enabling virtually collected electronically enabled work teams.

U.S. Army Aberdeen Proving Ground

The document management system at Aberdeen was implemented to streamline environmental assessment activities in accordance with the National Environmental Policy Act (NEPA). This system is very focused and relies on widely used database and groupware applications to perform document management and workflow (document approval and routing). Lessons learned from this approach are:

- It is very important to coordinate with all users (internal and external) when determining the requirements of the system, both hardware and software, prior to the commitment or expenditure of funds.

- The approach of customizing COTS packages such as Microsoft Word and Access and Novell Groupwise to fulfill specific needs of the organization has proved to be very cost effective. The alternatives of developing the entire system from scratch, or purchasing a complete EDMS and then customizing it to meet Aberdeen's needs specific to NEPA would have been far more expensive.

- It is important to have a contractor that you can trust and feel comfortable with prior to undertaking an EDMS implementation.

- The improved access to documents allowed by an EDMS can be inhibited by persons or organizations that believe documents are to be tightly held, not shared.

DOE Oak Ridge Center for Manufacturing Technology, Oak Ridge, Tennessee

As an early user of EDMS technology, dating back to 1987, DOE has learned a lot about the EDMS functionality needed to support its operations. According to Ms. Malarkey of the IT group, an EDMS capable of managing engineering and facility management documents should have:

- Robust versioning control and revision management to track what released version is in effect

- An ability to automatically capture file information (metadata) to ease future location and retrieval

- In the ORNL environment, consisting of model builders, approvers and end-users, Internet access by end-users (read-only) is critical; it supports electronic commerce and bidding.

- "Historical traceability" is needed to ensure current, at a given point in time, documents were used in production and manufacturing.

- Online commenting and approval, "similar to a yellow sticky note" is needed for the review and mark-up states.

- Even if native software files are managed by an EDMS, the EDMS must have the ability to manage neutral images, conforming with standards from ISO and others to avoid problems caused by frequent software version updates. Ms. Malarkey gave the example of, for instance, current word processors that in their third or fourth major release, and at some point will no longer be able to handle files from the early versions. If a neutral image format is not chosen for working documents, existing documents must be kept compatible by routine conversion to the latest version.

- Given ORNL's application, that relies heavily on 3-D models, neutral images allow end-users to view models without the need for the native modeling application.

7 The Role of The World Wide Web for Document Management

The Internet is becoming an integral part of a corporate infrastructure. Although much of the Internet is being used for corporate communication with customers, it is also being used to distribute published information within corporations. Termed Intranet, this internal use is essentially a private network created behind a firewall for corporate use. A firewall is an electronic security barrier that protects the internal network and the Internet servers from unauthorized access. These Intranets work in the same manner as the World Wide Web, but they operate only within the confines of an organization. They are used to publish globally documents such as price lists, rules and operations directives, manuals, engineering drawings (both released and in process), and almost anything else that needs to be accessed on a corporate wide-basis. The popularity of Intranets is due to the ease of implementation, the low cost, and the ease of using Web browsers. Intranets and the Internet use the same TCP/IP communications protocol and the Hypertext Markup Language (HTML), Web presentation language.

An electronic Web document can be text, image, CADD, voice, or video and can be sent anywhere within the organization regardless of computer operating system or platform. Web servers can be used as an extension of a corporate relational database allowing the information contained therein to be published through the Internet or the Intranet as desired.

The application of Internet technology to document management is a logical and natural progression. For some time, the majority of EDMS systems have used Internet technology as the core communications protocol for the transfer of data. This protocol is TCP/IP. The integration of a browser interface now allows rapid deployment of document management systems throughout the organization.

EDMS vendors are now providing organizations the ability to access their index and document repository from the Web. This Internet capability typically includes:

- HTML interfaces to let users identify and request documents
- Security provisions for restricting access to authorized users
- Transformation of documents from their native format to a more Web-friendly format such as HTML, PDF, CGM, or SVF

- Ability to download documents through Web servers and manage them as local documents while protecting the original document left on the Web server from modification

One of the key benefits of this capability is that special purpose "client" software does not have to be installed on the user PC's. In simple applications, the browser acts as the client. In more sophisticated applications, some level of processing may be done at the user's PC. In this case, the software is automatically downloaded the first time the user accesses the Web site and is updated when required. When needed, client software makes documents available to internal users as well as customers, suppliers, and other business entities. Documents can be viewed or downloaded and printed locally as needed.

Along with this technology, however comes challenges that are not apparent when working in a controlled hard-wired network environment. These challenges include:

Security

The security of the documents over the Internet is similar to the private network security on a standard LAN environment. One of the differences is that secure communication protocols such as the Netscape "Secure Socket Layer" will manage message passing security. Security relies on encryption of the data as it is physically moving between client and server. The DoD may need this type of security for highly secure documents but typically such security is not required for engineering documents. The standard EDMS security component determines who has access to documents whether the network is private or the Internet.

Communication of Document Status

When information from work in progress is made available to remote users, it is important to communicate that information may not be ready for publication or for its intended use. Document use limitations occur when documents are being revised or contain obsolete information. The EDMS should be able to determine whether a document may be viewed (published) over the Internet or Intranet, based on the document status or state.

Data Conversion

Internet browsers, such as Netscape and Internet Explorer, only offer support for HTML documents. Simple text based information can be displayed on browsers without problems. However, more sophisticated document formats such as Postscript, MicroStation, and AutoCAD cannot be readily displayed on a standard browser. Special software must be available to display these more sophisticated document formats within the browser. These software applications are called "plug-ins" and can support many formats. Some of the most popular formats for Engineering CADD documents include Computer Graphics Metafile (CGM) and Simple Vector Format (SVF). Both of these formats are vector formats that allow users to zoom in on the image without loss of resolution as would be the case with

scanned images. Products such as Bentley Systems ModelServer Publisher can be used to dynamically convert AutoCAD or MicroStation format documents to either CGM or SVF format, thereby making these files compatible with the browser plug-ins. CGM or SVF formats allow users to view native CADD documents over the Internet.

Viewing software such as Cimmetry Systems' AutoVue and Informative Graphics Myriad also provide browser plug-ins that allow the viewing and redlining of many different formats including engineering and desktop formats-CAD, Vector, raster, hybrid, word processor, spreadsheet, and database documents. These viewing systems are typically interfaced with the EDMS that allows for the delivery of the document to the viewer.

When CADD document access is needed to modify the original data in the file, no data conversion is necessary. In this case the CADD document is copied from the Web accessible server to the local client workstation without any format change. Standard CADD software is used to make the modifications and the document is then checked back into the server.

Speed of Access

Engineering documents tend to be much larger than typical business documents. The size of CADD files and images that are a result of scanning engineering drawings can cause very slow transfers over the Internet. Compression techniques can be employed such as publishing into more compact formats such as CGM and SVF. However, when transferring data in its native format, such as DGN or DWG, significant download times can occur. The Internet bandwidth continues to expand; however, the ever-growing number of users slows the net gain in bandwidth.

8 Conclusions and Recommendations

Conclusions

This report addresses the specific needs of DoD personnel responsible for facility design and management. The needs of facility designers and managers are unique because the management of engineering documents differs from the management of typical business documents in the following ways.

- Engineering drawings are large-scale documents, requiring large-scale scanning and plotting capabilities not required for typical business documents.

- Engineering documents are prepared by a number of persons from different disciplines and undergo an iterative series of quality and coordination reviews prior to reaching a "released state." Engineering documents have an extended in-process life, characterized by a dynamic, project-specific workflow. Pre-defined standard workflows, useful for business documents, are often too static to be used with engineering documents.

- EDMSs well suited to small-scale business documents can be linked to EDMSs particularly well suited to large-scale engineering documents to meet differing needs. A "one-size-fits-all" approach to EDMS is unnecessary and may be ineffective with today's EDMSs.

- A typical business document can have multiple authors, each working on particular sections simultaneously. Collaborative approaches have received much attention and promise improved creativity and efficiency. However, it would be dangerous to have multiple users modifying CADD files simultaneously. Any changes made by one contributor/discipline have the potential to impact upon designs by other contributors/disciplines. Therefore EDMSs for CADD files and engineering documents, unlike business documents, must prevent simultaneous modify access to files by multiple users.

- The engineering environment consists of many document types ranging from word processing to spreadsheets to engineering CADD files. A completed design can be made up of several or even dozens of file components, which can make engineering CADD files the most difficult for an EDMS to handle. A typical design is made up of a master file, reference files, and other associated files. To work on, or even display a completed design properly, these individual

files must be brought together for the CADD design software to function properly. This complexity makes the choice of EDMS software particularly crucial. EDMSs originally designed to manage simple text-based documents often are not well suited to handle engineering designs. However, EDMSs designed from the ground up to handle CADD files are able to manage complex engineering documents. Software that can handle engineering documents is generally adept at any document type, whether text, image, or other file formats.

- CADD drawings are unique in that they employ reference files. Without safeguards in place, reference file updates would not be reflected in documents retrieved after a particular document release (e.g., a set of bidding documents). An EDMS for engineering documents must be able to track drawing versions and/or freeze all reference files upon release of a document.

- CADD users often need to track the amount of time spent creating and modifying files and benefit from a session and application based accounting module in the EDMS. This feature has little benefit for most business document users.

Recommendations for Implementing an EDMS

EDMS is strategic to obtaining a competitive advantage. Intelligently designed and implemented EDMS technology can deliver significant productivity improvements.

Various sections of the report have presented particular suggestions and recommendations with respect to such items as defining your needs, integrating Internet/Intranet file access, and selecting a vendor.

Recommendations worth repeating or stressing follow.

- Clearly understand your existing systems and workflows to ensure that candidate EDM systems can be integrated into your organization.

- Establish a clear purpose and objectives for your EDMS. Be certain as to what document types the system must handle, how files will be entered into the EDMS, and how and if legacy data and systems are to be addressed.

- Recognize that cultural acceptance issues will arise and foster acceptance by involving stakeholders early and often. Some persons despise change and some may even subvert process enhancements.

- Take a calculated, methodical approach to EDMS implementation. Solve simple, bounded, and measurable processes first, ensuring that these are representative of the complexity of other processes your organization may handle. Select those processes that allow for an easy and measurable return on investment.

- Use a phased approach by implementing a pilot project to prototype the proposed system. This phased approach will ensure success and define the metrics used to demonstrate success.

- Incorporate incremental versus revolutionary changes in workflow (digitally enable first and re-engineer second). Choose an EDMS that is configurable enough to digitally enable or automate existing manual processes rather than require existing processes to be re-engineered.

- Remember that training likely will be needed during both pilot and production phase implementation and periodically thereafter.

- Be certain that your selected EDMS supplier fully understands your needs and expectations and has satisfactorily served other customers with like needs and expectations.

DoD likely should conduct one or more well-documented demonstration projects to show users how to identify their specific needs, identify and select a vendor, establish an acceptance plan, and implement the EDMS following a phased approach, including training at appropriate stages. To the extent possible, all tangible benefits of implementing an EDMS should be quantified and compared to EDMS costs to determine the return-on-investment (ROI).

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