ADVANCES IN ENGINEERING DATA HANDLING

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Edited by

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PREFACE

To understand what we know
and be aware of what is to be known
has become the central focus
in the treatment of engineering data handling issues.

It has been some time since we began treating issues arriving from engineering data handling in a low key fashion because of its housekeeping chores and data maintenance aspects representing nonglamorous issues related to automation. Since the advent of CAD/CAM, large numbers of data bases have been generated through stand alone CAD systems and the rate of this automated means of generating data is rapidly increasing. This possibly is the key factor in changing our way of looking at engineering data related problems.

This volume contains some of the papers, including revisions, which were presented at the fourth Automation Technology conference held in Monterey, California. This volume represents ATI's efforts to bring forth some of the important case studies related to engineering data handling from the user's point of view. Because of its potential enormous impact on management and productivity advancement, careful documentation and coordination for outstanding contributions to this area are of utmost importance.

This volume may serve as a precursor to additional volumes in the area of engineering data handling and CAD/CAM related user studies. Anyone with comments or suggestions, as well as potential contributors, to this series, is encouraged to contact the editorial board of ATI.

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ADVANCES IN ENGINEERING DATA HANDLING

1

DIGITAL DOCUMENT MANAGEMENT SYSTEM USING OPTICAL DISK MASS STORAGE

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Abstract

Three technological breakthroughs make the concept of an all digital document management system realizable. They are the optical disk mass storage, error-free digital transmission and revisory* capability with respect to scanned documents. Optical storage and error-free transmission makes the system technically feasible. Revisory makes the whole notion of the all-electronic system viable in that it allows, for the first time, existing documents to be modified electronically resulting in huge cost savings to industry and government.

1. INTRODUCTION

A major problem confronts industry and government which substantially interferes with their productivity. It is the inefficient and costly manner in which large volumes of existing drawings are managed and handled in support of the critical processes of design, manufacture, storage, and maintenance. Although computer technology is being effectively applied to improve design and, to an increasing extent, manufacturing processes, it has not been applied to the problem of storing, retrieving, revising, and printing existing hard-copy (vellum, paper or film) drawings which accumulated before the advent of CAD/CAM.**

Hundreds of millions of these pieces of artwork have been accumulated as hard copy which must be physically stored and actively used, despite the trends to use new computer-aided design techniques. This hard copy artwork constitutes a heavy burden to designers and draftsmen who must modify drawings, to technical manual producers who must revise drawings frequently for maintenance purposes, and to management personnel who must maintain drawing libraries, preserve drawings, and distribute drawings.

STC and ALPHAREL extensively studied the document management problem and have conceived of unique high technologies for serving the needs of industry and government

*Having the "Power" to Revise; Websters Dictionary
**Computer Aided Design/Computer Aided Manufacturing

agencies. Computer, optical and communications technologies are integrated in a way as to greatly reduce workloads and costs and greatly simplify and facilitate the handling of hard copy artwork (and accompanying text).

The techniques enable industry and government agencies to capture hard copy artwork automatically and rapidly, store them in an electronic form, revise or edit them electronically on a TV-like screen, print them out very rapidly as hard copy (paper, film or microfilm) and automatically distribute them locally or remotely.

This paper describes the innovative technological breakthroughs - optical disk mass storage, error-free digital transmission and revisory capability and how they are integrated into an effective electronic Digital Document Management System.

2. REQUIREMENTS OF A DIGITAL DOCUMENT MANAGEMENT SYSTEM (DDMS)

The DDMS must have the capability to resolve the major problem confronting industry and government - the effective management of very large numbers of manually created documents. The DDMS must be capable of automatically, rapidly and in a virtually error-free way transfer documents from vellum or film into compressed digitized mass storage thereby enabling retrieval, display, distribution and revisions to be accomplished electronically at a small fraction of the manual cost. The DDMS must be modularly expandable hardware and software wise to guarantee its utility over extended periods as user requirements evolve; i.e. the system should not have built in obsolesence. The DDMS must provide for efficient and effective management and control of the stored documents.

Specifically, the DDMS must be capable of meeting the following requirements:

2.1 AUTOMATIC SCANNING

Drawings on paper, vellum or film must be scanned automatically and the output into a digital form as required to be accessible by a computer. Resolution should be user selectable (See Tables 1 and 2 in Appendix A) and scan times consistent with document format, resolution and compression algorithm. Typically, the scan time for an "A" size document at a resolution of 200 lines per inch (lpi) should be approximately three seconds. Intermediate resolution (300 to 400 lpi) documents should be captured in 20 to 30 seconds and high resolution (1000 lpi) artwork should be captured in approximately one minute.

2.2 DIGITAL DATA COMPRESSION

The digital representation of drawings must be reduced (compressed) to minimize the size of storage and cost of communications. The compression algorithm should be adaptive to operate consistently within document scan times. Compression should be at least 10:1 for fast scan, "A" size drawings at 200 lpi, 15 to 20:1 for intermediate resolution (300 to 400 lpi) and 30 to 40:1 for high resolution (1000 lpi) documents.

2.3 MASS STORAGE OF DOCUMENTS

The DDMS must provide for low cost optical mass storage which can be modularly expanded up to at least 2000 gigabytes to accommodate users' evolving drawing count and in accordance with the selected resolution (See Tables 1 and 2 in Appendix A). Most important the optical disk mass storage must operate under an existing operating system. It should not be required to develop new system software to accommodate the optical disk.

2.4 TEMPORARY MAGNETIC STORAGE

The DDMS should provide magnetic disk and tape drives for temporary storage and for loading operating system software and user application software.

2.5 MAINFRAME COMPUTER

System processing should be capable of handling present needs - storage, retrieval, display, revision and printout and provide for future electronic distribution of documents. Host computer and communication peripheral software should be available to accommodate these requirements. It is also highly desirable for the system mainframe computer to be capable of operating with the vast store of existing software packages such as CADAM. This feature would increase the utility and life cycle of the DDMS.

2.6 DISPLAY AND PRINT OUT OF DOCUMENTS

In response to a display request for a document the DDMS must be capable of rapidly

retrieving, expanding and displaying a sampled version of the document on a graphics monitor. The system must be capable of blowing up the picture depicting more and more of the actual pixels so an operator can see a section of the document at the scanned resolution.

Similarly, in response to a copy request the DDMS must retrieve, expand and print out hard copy at originally scanned resolution or at the resolution designated by the operator. High resolutions (1000 lpi) print time for a "C" size drawing should not exceed one minute. Print out time for an A size document at 200 lpi should not exceed eight seconds.

The system should be capable of driving optional high resolution output modules, computer output microfilm (COM) - both the Cathode Ray Tube (CRT) and Electron Beam Recorder (EBR) versions and the phototypesetters. These options should include the capability for outputting scanned art and text.

2.7 DOCUMENT REVISION

When revisions or updates of a document are required the system must automatically retrieve and present the stored document on the CRT display and allow the operator to interact with that display and insert changes desired. Revisions may consist of text line art or both.

2.8 DOCUMENT DISTRIBUTION

The system must provide electronic distribution and enable electronically stored drawings to be revised from a remote work station interactive terminal.

2.9 MANAGEMENT AND CONTROL

The DDMS system must provide an efficient, secure virtually error-free system for the management and control of the library of documents. The system should be flexible to accommodate a users standard for assignment of documents and revisions, maintenance of distribution lists, maintenance of master version for security purposes and restriction of access to documents.

3. DESCRIPTION OF DIGITAL DOCUMENT MANAGEMENT SYSTEM (DDMS)

The DDMS will automate the electronic capture of manually created documents, engineering drawings or technical manuals and store the data in compressed electronic format in a central data base. As needed documents can be retrieved, displayed, revised electronically and printed out if required either locally or at a remote site. DDMS is a significant technological breakthrough - using optical disk mass storage, high resolution scanning and compression, error-free digital transmission and electronic revision - for it brings to manually created documents benefits previously available only with those originated in electronic format. The modularity of DDMS and its compatibility with the huge store of existing IBM software guarantees the system against obsolesence. The powerful capabilities of DDMS will have a profound impact on productivity of the entire document management process.

The DDMS is highly modular and may be minimally configured to meet present needs and be modularly reconfigured to meet expanding requirements at a later date. The "basic" DDMS components are depicted in Figure 1 and are described in Part A below. Part B describes the optional equipments which may be added as requirements evolve.

A. BASIC DDMS COMPONENTS

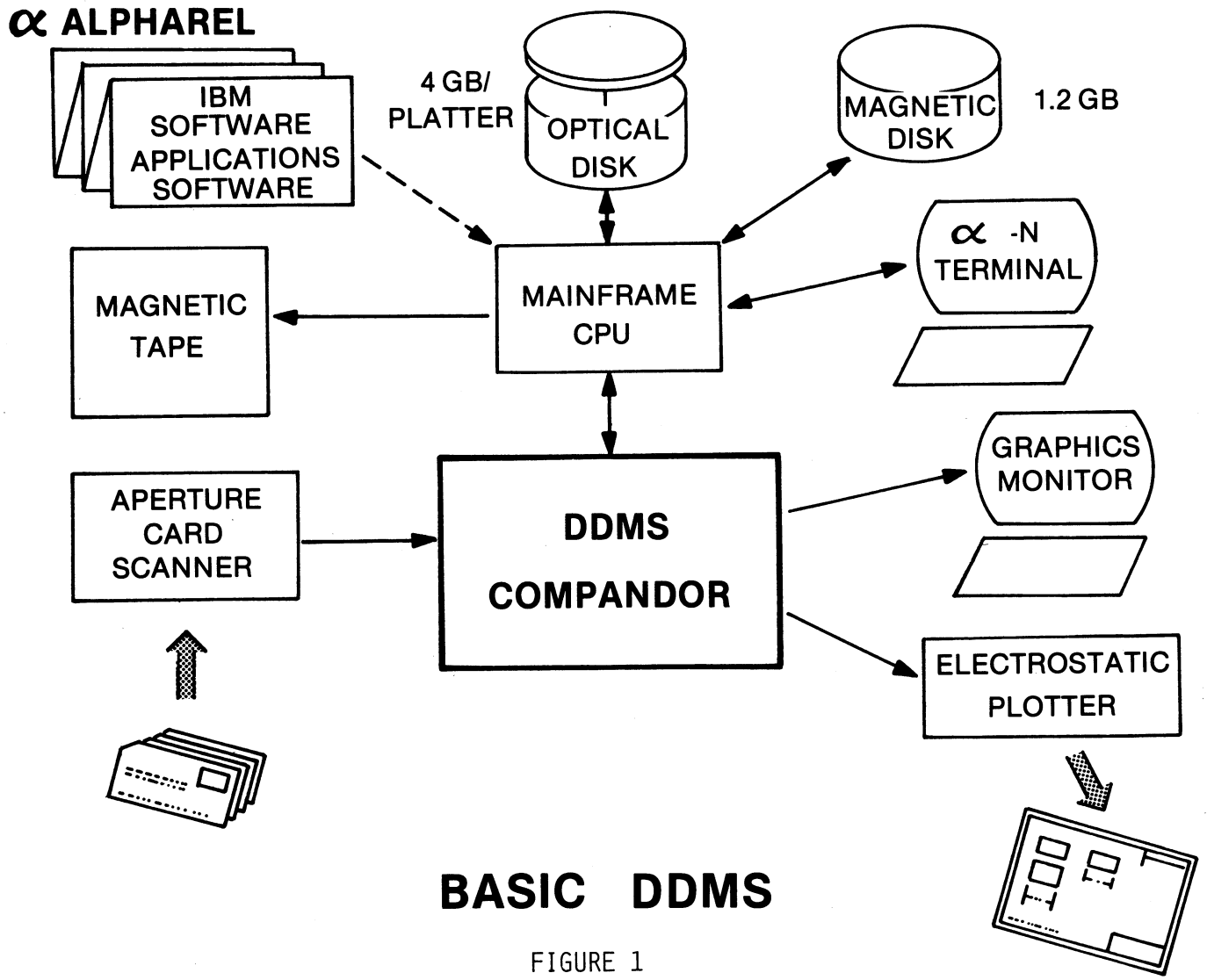
1. Optical Disk Mass Storage

The optical disk mass storage system is designed to modularly accommodate digitized drawings (or documents) in accordance with volume, format and resolution. Actual storage required is a function of these parameters and can be quantified in terms of specific customer needs by referring to Appendix A.

A customer can start out with a basic system containing 4 gigabytes optical platters each. The scanning and digitization processing begin by storing the recorded platters offline. Later on, when the need arises, these same digitized platters can be integrated into the Automatic Archive Unit (See B1 below). A crucial feature of the optical disk drive and control unit is that it operates under IBM Operating Software with only minor changes required of the host software. This meets important immediate requirements of the DDMS and will contribute significantly to its life cyle.

2. Magnetic Disk Temporary Storage

The STC 8000 provides temporary magnetic disk storage. The subsystem consists of the



BASIC DDMS

FIGURE 1

STC 8000-5 Controller and STC 8650 High Density Disk Drive.

a. STC 8000-5 Disk Controller - The STC 8000-5 connects directly to the computer via the standard IBM channel controller and controls up to four STC-8650 disk drives.

b. STC 8650 Disk Drive - The 8650 is dual density disk providing 635 megabytes of data per spindle or a total of 1.27 gigabytes per unit. A typical configuration would consist of the 8000-5 controller, a two-spindle A2 unit drive and up to three B2, two-spindle devices.

The Magnetic Disk System is compatible with IBM Operating System Software.

3. Magnetic Tape Storage

The STC 4550 Tape Subsystem consists of an "A" Unit which includes a single tape drive and the formatter for dual density operation - 1600 or 6250 bits per inch. The STC 4550 interfaces directly to the computer via the standard IBM Block Multiplexer Channel. Additional STC 4554 Tape Drives may be added up to a total of eight.

The Magnetic Tape Storage System is compatible with IBM Operating System Software.

4. Computer

The Magnuson 8030 mainframe computer is compatible with IBM Operationg System Software and provides significant capability for expansion and use of existing software. The device is plug-for-plug compatible with devices manufactured by a multitude of vendors including IBM, IPL, and Amdahl. (STC also has a compatible system under development and scheduled for delivery in the third quarter of 1983). Continued mainframe support - hardware and system software is assured by this compatibility.

5. Alphanumeric Terminal

The Alphanumeric Terminal consists of the following:

a. IBM 3274 Control Unit - Can control up to 32 display stations and printers for standard channel attachment to the computer.

b. IBM 3278 Display Station - Table top display displays 960 to 3564 characters per screen depending on the model.

These units operate under IBM System software.

6. Graphics Monitor/Print Out

Many options are available for use in conjunction with ALPHAREL'S COMPANDOR. A basic graphics monitoring capability consists of a version of Genisco G-1000 Terminal configured with 512K bytes of expansion memory and the hard copy interface for the Tektronix 4631. This capability provides a 1K X 1K display with scrolling of drawings at the sample rates depicted in Figure 2. Output print is limited to the format of the Tektronix 4631.

7. Plotter

The basic system 200 lines per inch output capability is provided by the Versatec Electrostatic Plotter 8222A (22" width) or 8242A (42" width). Higher resolution options are described below under B5.

8. A Size/Aperture Card Scanner

A basic DDMS should be equipped with either an A size 200 lines per inch document scanner or an Aperture Card Scanner.

a. Terminal Data Corporation (TDC) Docuscan Scanner - The TDC Docuscan Scanner provides for scanning A size drawings at 200 lines per inch in one-half second. Slower speeds can be utilized to enable high data compression.

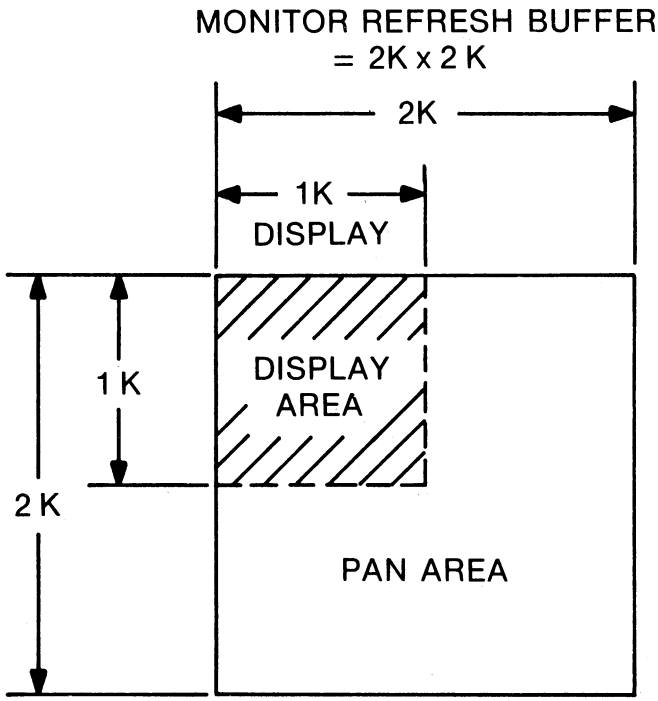
b. ALPHAREL AR-CCD Aperture Card Scanner - The ALPHAREL AR-CCD Aperture Scanner provides optional resolution selections as shown in Appendix A and provides up to 350 lines per inch on an "E" size drawing reduced 30 times. Scan times for the scanner are approximately 10 seconds for an E size drawing at 200 lines per inch. Scan times are correspondingly less for smaller drawings.

9. Data Compression/Decompression

ALPHAREL's COMPANDOR AR32SP, Modules B and C are special purpose processors designed to optimize the real time companding (compression/expansion) operation to keep storage and transmission costs minimal.

FIGURE 2

MONITOR DISPLAY



DRAWING SIZE	INCHES	#PIXELS @200 LPI	REQUIRED SAMPLE RATE OF ORIGINAL*
A	8½ X 11	1700 X 2200	100%
B	11 X 17	2200 X 3400	66% (2 of 3)
C	17 X 22	3400 X 4400	50% (1 of 2)
D	22 X 34	4400 X 6800	33% (1 of 3)
E	34 X 44	6800 X 8800	25% (1 of 4)

*IN VERTICAL AND HORIZONTAL DIRECTIONS

The COMPANDOR is a proprietary design of ALPHAREL which also has the unique capability of being modularly expanded to provide communications (See Option B4 below) and to allow revision of scanned documents (See Option B3 below).

10. Software

a. Operating System - IBM's Disk operational System/Virtual Store (DOS/VS) has been selected over Virtual Machine (VM) as the optimum choice for the DDMS application. DOS/VS has all the resources required and are fully supported and they're well tested and sufficient for this application. An attractive feature in a DOS/VS environment is that which allows all available resources to be measured through hardware and software monitoring devices. This is not easy to do in other operating systems. DOS/VS also requires much less RAM and disk space, fewer processor cycles, less IBM maintenance and is less difficult to install than VM.

b. Application Software Package - Six modules provide the basic functional capability to scan, digitize, store, retrieve, display, distribute and print out drawings. The modules are: Task Manager, Directory Control, Scanner, Input, Display and Printer Output and Communications. Other modules including drawing revision may be added as required.

B. OPTIONAL DDMS COMPONENTS

The DDMS can be optionally configured in accordance with evolving requirements; capabilities need to be implemented only when needed. The major optional components are depicted in Figures 3 through 7 and are described below.

1. Automatic Archive Optical Disk Unit

The Automatic Archive Optical Disk Mass Storage System developed by STC can accommodate up to 4 optical disk drives and can contain 256 optical disk platters for a total storage of 1024 Gigabytes. A complementary storage module can be attached to accommodate up to 2 additional drives and 256 platters making the total capacity for both modules 2054 Gigabytes if all 512 platters are loaded.

The STC optical disk platters are nominal in cost $150 each) and it would be practical to load extra storage for future increases in drawing storage or for increases in resolutions that might be required for special programs. If the higher resolutions described in the appendix are selected there is more than adequate storage available in the archive system.

The DDMS has the capability to direct the Archive Optical Disk System to write the drawing as it is scanned, simultaneously on two different optical disk platters providing a complete second drawing file for backup.

2. Document Scanner (Large Format)

a. ALPHAREL Laser Scanner - The ALPHAREL AR 1000S Laser Scanner can be selected to scan drawings up to "C" size in less than one minute at a resolution of up to 1000 lines per inch. Larger formatted and roll size drawings required photographic reduction to C size format. Resolution for the reduced drawings would be lower by the reduction ratio.

The laser scanner looks like a magnetic tape to the mainframe computer and is compatible with IBM software.

b. APHAREL Camera Subsystem, AR-36

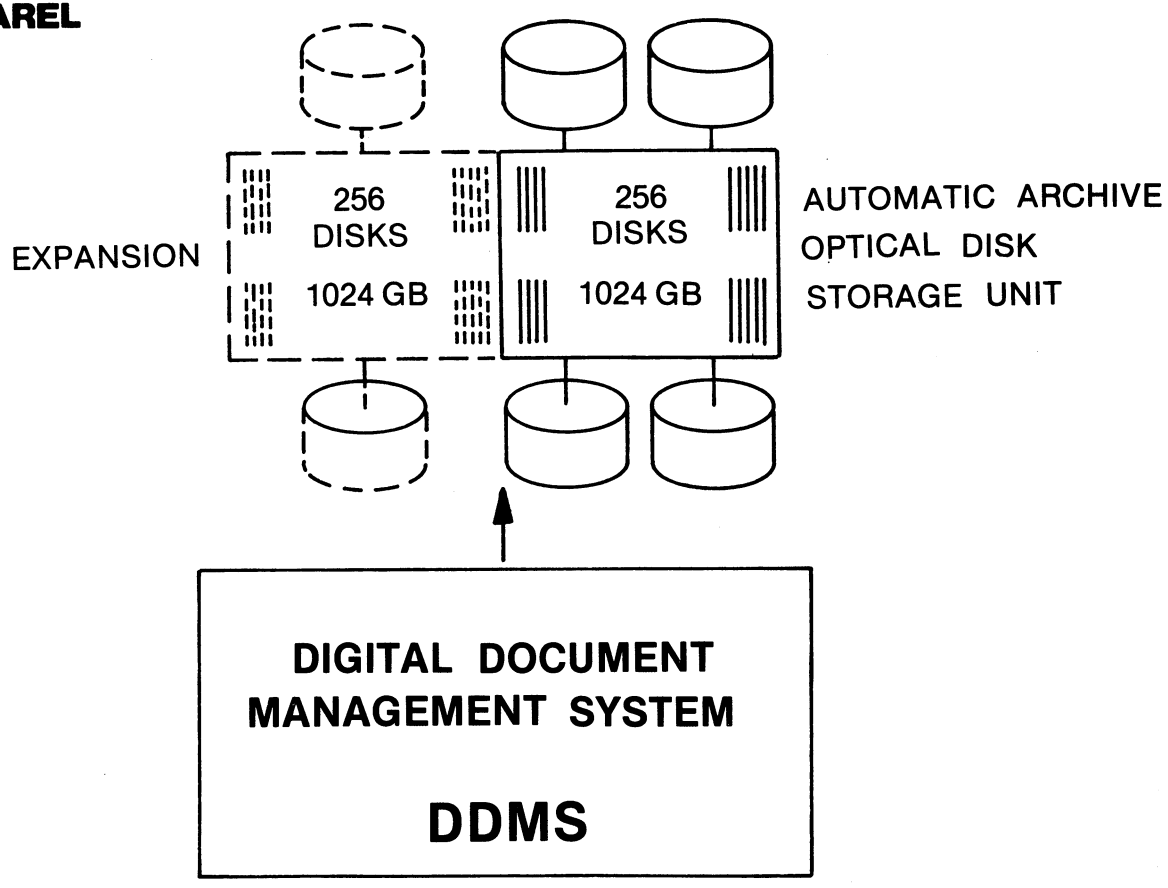
1) Log-E-Tronics Copy Camera, Number 2424-LB - The Log-E Tronics Camera photographically reduces drawings or drawing sections having larger than "C" size formats prior to the scanning and digitization process by the laser.

2) Log-E-Tronics Film Processor, Number RAP-24 - The RAP-24 is a versatile, fast, automatic processor for handling variable materials - laser dot generated images, dark room and daylight contact materials, and RC paper.

3. Interactive Graphic Revision Terminal

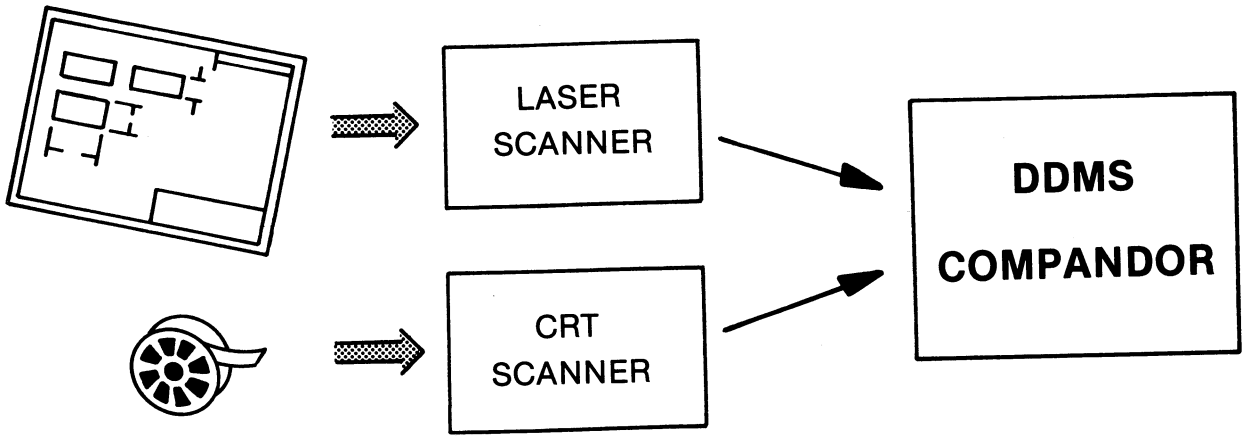
ALPHAREL's innovative COMPANDOR, REVISORY, Module (D) provides a unique capability to interactively revise scanned drawings without the need to re-draw or re-scan them. This feature will contribute significantly to savings or cost avoidance efforts by improving productivity by as much as 20:1 the management of drawings inside the electronic data base over those manually managed.

α ALPHAREL



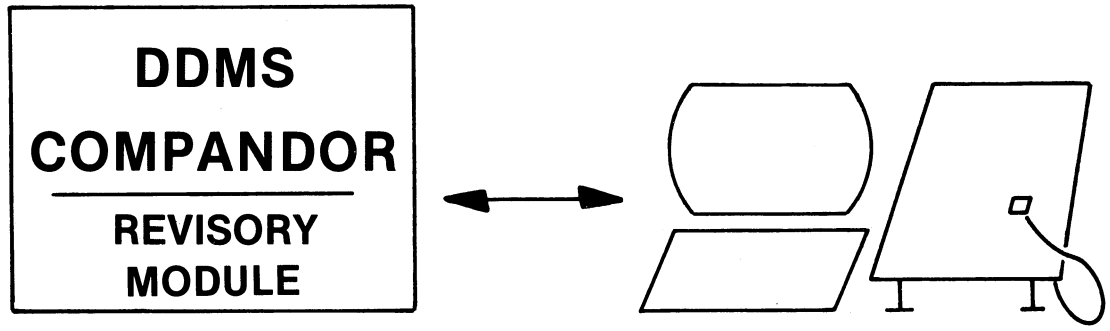
AUTOMATIC ARCHIVE STORAGE OPTIONS

FIGURE 3



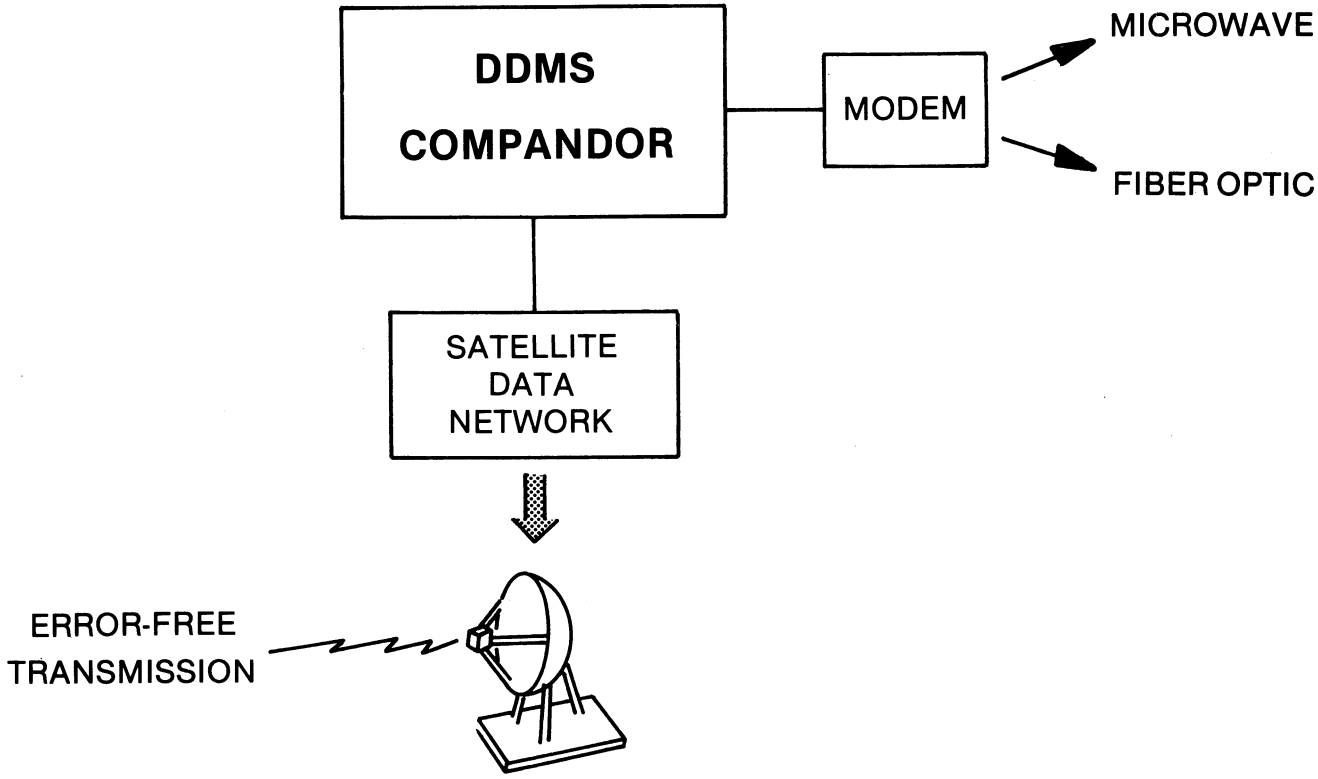
INPUT OPTIONS

FIGURE 4



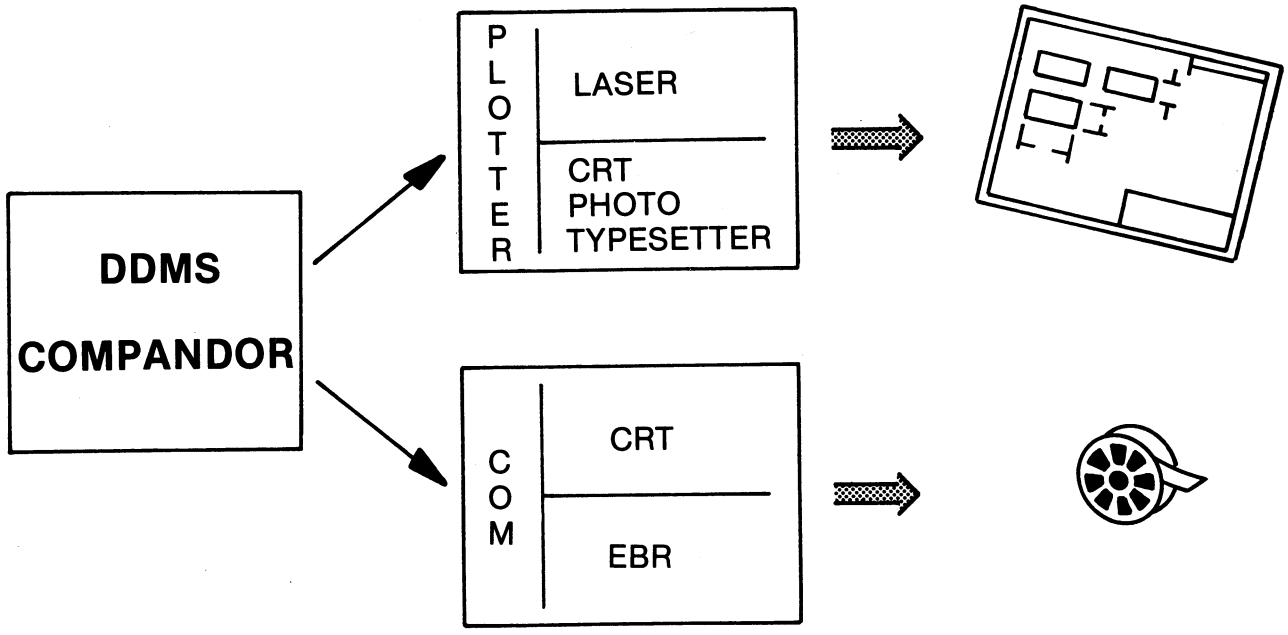
REVISORY OPTION

FIGURE 5



COMMUNICATIONS OPTION

FIGURE 6



OUTPUT OPTIONS

FIGURE 7

4. Communications Processors

   a. COMPANDOR, Module A provides communications hardware and programmable protocol to accommodate local and remote interface requirements. Fiber optic lines can be employed within multiple building complexes up to a few kilometers. Microwave links can be used for larger distances up to 20 to 30 miles.

   b. Satellite Data System, 1720, can be used to link remote sites via the high speed error-free digital link. Computers located cross country can communicate with each other at rates up to 6.3 megabits per second. The unit can also be used to filter noisy terrestrial links.

5. High Resolution Plotter

ALPHAREL's Laser Printer provides a high resolution capability for printing drawings at resolutions of up to 1000 lines per inch for format A through C. Larger formatted drawings can be scaled down in the COMPANDOR and outputted on the "C" size laser. The drawings can be photographically expanded to full size or conversely reduced to give high resolution 35mm COM output.

The laser printer looks like a magnetic tape to the mainframe computer and operates under IBM software.

6. Computer Output Microfilm (COM)

   a. High Resolution - Direct recording, high resolution COM in excess of 200 lines per inch can be achieved with the Image Graphics, EBR 2000 Series Electron Beam Recorder (EBR). The EBR equipment is interfaced to the computer via the COMPANDOR.

      The COMPANDOR looks like a magnetic tape to the mainframe computer and operates under IBM software.

      Alternatively, high resolution COM recordings can be achieved by first recording on ALPHAREL's Laser Printer and reducing the large format to 35mm photographically (See Option B5 above).

   b. Cathode Ray Tube - COM - Limited resolution COM output can be achieved at a lower cost via the Autologic APS-51 Microfilm Recording Unit. Resolutions of approximately 158 and 126 lines per inch can be achieved for D and E size drawings reduced 30 and 24 times respectively. Smaller (A-C) size drawings which are reduced 16 times would be recorded at correspondingly higher resolutions (236 lines per inch).

   c. COM Photo Processor - The Eastman Kodak Versamat Model 75 Processor processes 16mm, 35mm and 105mm film width.

7. High Speed Printer

The STC Documation Universal 1000 Printer provides the DDMS computer with a data processing output print capability of 1000 lines per minute field upgradable to 1600 lines per minute. The STC 1000 Printer is interfaced to the mainframe computer via the standard IBM channel.

8. Magnetic Tape Drives

Additional STC 4554B units or tape drives can be added up to a total of eight for each STC 4550 Subsystem.

3. COST JUSTIFICATION OF DDMS

The DDMS provides great productivity gains and cost reductions in overall management of existing manually created drawings by furnishing the means for automatic low cost capture of these drawings in a useable electronic format in a reasonable length of time. Once the drawings are digitized the well proven productivity gains (ADL Study) formerly available only for electronically created drawings are then available with DDMS for the manually created drawings which comprise the vast majority of drawings in use by industry and government.

This drawing data base will grow even greater in the forseeable future for even those organizations heavily committed to CAD/CAM have a tremendous accumulation of conventionally created drawings to which each day they add many new manually created drawings. This is because they still create many more drawings manually than electronically and even with increasing use of CAD/CAM the manually created data base will continue to grow even larger for decades to come.

The inexorable growth of this manually