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AUTOMATIC DOCUMENT STORAGE AND RETRIEVAL SYSTEMS.(U)

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Automatic document storage and retrieval systems are currently available in a variety of forms. In a survey of the marketplace, these systems were compared for the storage of engineering drawings. They were characterized mainly by the type of memory device used—magnetic tape or disk, laser mass memory, microfilm, and microfiche. None matched the idealized system described in this report. New memory devices are under development: homograms, ovonic memories, magnetic — over

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bubble memories, and vesicular film. A microfiche system for an existing engineering program, a magnetic tape or disk system for starting a new program, and a combination of the two for a large ongoing program are recommended.

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1. INTRODUCTION

In 1974, the U.S. Army Materiel Command (now the U.S. Army Materiel Development and Readiness Command) requested the Harry Diamond Laboratories (HDL) to survey the marketplace for automatic document storage and retrieval equipment that might offer an alternative to the Mosler 410/40 System for the mass storage of engineering drawings. In addition, HDL was to provide detailed information on any development that was underway to improve, design, or specify a storage and retrieval system for the future. At that time, it was found that some development was underway, but there was little or no effort to design or specify a complete system for the future. In an informal HDL report of July 1974,* a start was made in this area by specifying an idealized system of the future (app A). The specifications were not intended as final, but only as a starting point for discussion. No existing system at that time satisfied all of the requirements, but a few that came close were briefly described. Many systems were eliminated immediately because they had small storage capacity, took excessive access time, or were semiautomatic. This report surveys the marketplace and estimates how much progress has been made toward the goal of the idealized system. The primary reference sources for the information contained here are private communications with the system users, manufacturing companies, and government agencies cited. The systems are characterized mainly by the type of memory device used.

The systems that were previously described were the Ampex Videofile, Trans-A-File, Precision Instruments System 190, Image Systems, Dynamic Information Systems, and the Mosler System.

**Survey of Automatic Document Storage and Retrieval Systems, Harry Diamond Laboratories (July 1974).*

Of these, two have gone out of business, one has changed hands, and one has changed the company name. All of the companies still in business report improvements in their systems. In addition, several new memory devices that promise to further improve the art are now in various stages of development.

2. PREVIOUSLY REPORTED SYSTEMS

With reference to the previously described systems, the following changes have taken place since the last report.

2.1 Ampex Videofile

The Ampex Corp. of Redwood City, CA, is still manufacturing its Videofile Information System, which converts documents into compact images on magnetic tape. This is accomplished by a system similar to that of a television (TV) camera with video taping. Commercial TV has 525 lines in each picture, whereas Videofile has 1280 lines in each picture. Documents are stored on 2-in. (5.08-cm)-wide magnetic tape with the address track along one edge and the control track along the other edge. A document 8-1/2 × 14 in. (~22 × 26 cm) (current maximum size) requires a 1/3-in. (0.8-cm) linear tape length, with a maximum reel length of 4800 ft (1440 m) and with a 12-1/2-in. (32-cm) diameter. The maximum number of documents per reel is 166,600. The same problems exist as were reported before to meet our requirements for the storage of engineering drawings, namely, that a much higher resolution would be required (approximately 6000 lines per picture) that would generate 25 times as much uncompacted data, thus reducing the number of documents per reel to 6664.

The system requires a Control Section, which can drive up to seven Tape Sections, one or more Buffer Sections, one or more Display Sections (visual output device), a Filing Section (basic document input section including TV camera), and a Printer Section (electrostatic printer for hard copies). The current cost of a Control Section is about $100,000; Tape Sections are likewise $100,000 each, as are Buffer Sections. Display Sections are $15,000 each, and Filing Sections are $50,000 each.

Five installations are in operation, one of which is at Ampex. The other four are at the Southern Pacific Railroad in San Francisco, CA; American Republic Insurance Co. in Des Moines, IA; Royal Canadian Mounted Police in Canada; and New Scotland Yard, London. This last one, a 4-1/2 million dollar installation, put into operation 1 year ago, consists of two graphic systems: one is a main collection file for criminal records, and the second is a scene-of-crime system for latent fingerprints.

The advantages of this system are the simple access and the file revision capability. Images can be selectively erased and replaced easily. The disadvantages are the limited storage capacity and the high cost of storage per document. The archival lifetime of a magnetic tape that is searched frequently also is questionable.

2.2 *Trans-A-File*

The Trans-A-File Co. went out of business in 1976. It had installed systems in only two locations by that time, one at the Medical College of Virginia in Richmond and the other at an insurance company in Philadelphia. This was a magnetic tape image storage system that located images with an absolute address on the tape. The system was inferior to the Ampex Videofile in that it used a smaller tape width (1 versus 2 in.—2.54 versus 5.08 cm) and had more control track requirements, thereby getting only about one fourth the amount of data on a reel of tape. In addition, document quality suffered due to its two-level digitization process versus the 10 grey levels in the Ampex system.

2.3 *Precision Instruments System 190*

The Precision Instruments Co. has recently changed its name to Omex, but is still located in Santa Clara, CA. The System 190 is now called the System 1800 Laser-Optic Storage Unit, and it is a subsystem of the company's Records Management System 180 (RMS-180). The RMS-180 is a complete facsimile document storage and retrieval system designed to replace paper files. The Filing Unit can accommodate a document of any size up to 8-1/2 × 14 in. on any kind of paper in any color.

In addition to being the storage subsystem for the RMS-180, the System 1800 may be purchased separately for use as a laser mass memory system. With conventional interface to a host computer, it provides on-line mass storage; or it can operate in a stand-alone environment functioning independently, since integral to the System 1800 is a control minicomputer that contains programs necessary for the correct monitoring and control of all the System 1800 components.

The recording medium, called the Data Strip®, is a polyester sheet onto which a thin coating of rhodium metal is deposited. A precisely controlled modulated laser beam changes the reflectivity of microscopic spots on the Data Strip, forming a digital binary bit pattern. When the laser beam reads the pattern, the power is reduced so that it no longer affects the strip surface, and the reflected light is monitored.

Each Data Strip can store up to 2×10^9 bits, of which over 1.6×10^9 bits would be user data. A Data Strip pack consists of 10 Data Strips, and each System 1800

Read/Write Unit can contain up to 8 Data Strip packs or 80 Data Strips with a total storage capacity of 128 × 10^9 bits of user data.

A distinct advantage of this system is the archival quality of the recording media. Since data are read by monitoring reflected light, there is no degradation from friction or wear. Likewise, they are unaffected by electromagnetic radiation, computer power failure, or other environmental disturbances. The data do not deteriorate, print through, or wear out.

A disadvantage is that the error rate is not so good as that of a magnetic disk (a probability of 10^{-7} versus 10^{-9}). This rate could be improved by redundant coding, but at a sacrifice of storage capacity and speed. A small RMS-180 costs about $800,000.

2.4 *Image Systems*

Image Systems, Inc. (ISI), of Culver City, CA, is still manufacturing the CARD (Compact Automatic Retrieval Display) system, which consists of a carousel containing 780 microfiches with an automatic retrieval mechanism. The outer edge of each microfiche has a metal strip with coded notches that uniquely identify it. The carousel is rotated past a sensor, and the desired microfiche is located, extracted, and positioned in a projector to display the specified frame. The entire process takes 3 s or less.

The capacity of the system, using conventional microphotography reduction of 30X, which allows 14 E-size (34 × 44 in.--86 × 118 cm) drawings per 4 × 6 in. (10 × 15 cm) microfiche, thus is 14 × 780 or 10,920 E-size images. As was reported in July 1974, if the images were stored as Fourier transform holograms, 600 images per microfiche would be attainable, thus increasing the capacity to 600 × 780 or 468,000 E-size images. However, holographic image optics are still not available from ISI.

An available option with the system is a large screen display up to 3 ft. (0.9 m) square. A Questicon Corp. minicomputer is an available and desirable option, as is a hard copy printer. The current price of the ISI 2000 system is $6900 with no options, $2500 extra for the computer, and $3000 extra for the printer. The U.S. Patent Office has such a system, and for a small scale system it appears to be quite satisfactory.

2.5 *Dynamic Information Systems*

In July 1974, Dynamic Information Systems was manufacturing a system that combined up to nine ISI microfiche mechanisms and a magnetic disk file. However, we have been unable to locate the company and, therefore, must assume that it is no longer in business.

2.6 *Mosler System*

The Information Systems Division of the Mosler Co. was sold in 1975 to Infodetics of Anaheim, CA, including all patent rights to the Mosler 410 Storage and Retrieval System. Infodetics is now producing the Infodetics 410/45 Information System using aperture cards as the storage medium and the Infodetics 410/50 Information System using microfiche as the storage medium. Both systems can be controlled by local or remote keyboards or a computer, and they automatically present to the user information in the form of video display, duplicate microform or microfiche, or hard copy output. The 410/45 unit stores 200,000 Hollerith card documents, and the 410/50 unit stores 150,000 microfiches 105 × 148 mm. As many as 47 file modules may be connected to a single central control system, thus giving a storage capacity of 47 × 200,000 or 9.4 million Hollerith card documents or 7.05 million microfiches. The current price is about $260,000 for the base system and $115,000 for each extra file module unit.

The system now incorporates a Data General NOVA 3D minicomputer and does not need to time share with a large computer. A Scan/Zoom TV transmitter at the output station is priced at $31,200, and a remote terminal station consisting of a 17-in. (43.1-cm) TV monitor, a keyboard, and a Scan/Zoom control is priced at $5700. Up to six remote terminal stations can use one Scan/Zoom TV transmitter on a time sharing basis.

The area of prime concern with the old Mosler System of July 1974 was related to the cost effectiveness of the remote TV terminal capability. This concern is eliminated with the Infodetics innovations.

The system now uses an Océ 3750 automatic microfilm enlarger/printer (Océ Industries, Inc., Chicago, IL), which makes precision prints from microfilm in size A (8-1/2 × 11 in.) through size E (34 × 44 in.) drawings. The print size is automatically linked to the paper size with variable override magnification between 7.4X and 30X. The cost of this option is about $26,500.

The following Army installations are using the Infodetics storage and retrieval system: U.S. Army Tank Automotive Readiness Command, Michigan (six units); U.S. Army Missile Defense Command, Alabama (nine units); U.S. Army Aviation Systems Command, Missouri (three units); and Picatinny Arsenal, New Jersey (two units). In addition, the Defense Logistics Agency, Richmond, VA, is installing the unit, and the Defense Equipment Supply Command, Dayton, OH, also has a unit, as does the National Security Agency, Maryland.

3. NEW OR IMPROVED SYSTEMS

Additional systems have come on the market since July 1974, as well as improvements in systems existing at that time, and now qualify for consideration. While it is still true that no system satisfies all of the requirements for the idealized system of the future as specified in the July 1974 report, more systems are approaching this goal.

3.1 *Access System M*

The Access Corp. of Cincinnati, OH, produces an automatic mass document retrieval system called System M. The heart of the system is the Access card, in which the memory is recorded by notching a distinctive code into teeth on the bottom of a specially fabricated, plastic-treated card. The file documents, which measure either 3-1/4 × 7-3/8 or 5 × 8 in. (7 × 19 or 13 × 20 cm), can be opaque cards carrying written, typed, and printed information, aperture cards, microfilm jackets, or Universal Carriers (transparent envelopes into which other documents can be inserted). One System M Mass Module can contain up to 100 cartridges. The capacity of a cartridge varies depending on the media used in the system. The maximum capacity is 2000 opaque cards, with capacity decreasing when thicker documents and Universal Carriers are used. Assuming one 7-mil (0.18-mm)-thick microfiche per Universal Carrier (8 mils—0.2 m—thick), one cartridge can store about 1000 microfiches. A 100-cartridge Mass Module therefore has a storage capacity of 100,000 microfiches. Up to 16 Mass Modules may be driven by one Index Control System (ICS), which is a process controller containing a preprogrammed minicomputer. A system such as this has a storage capacity of 100,000 × 16 or 1.6 million microfiches. The current price is about $140,000 for a 100-cartridge Mass Module and $125,000 for the ICS.

The average search time for the System M is 9 s from entering a code on the keyboard to retrieval of document.

The following Army installations are now using the Access System M: the correspondence control for the Office of the Secretary of the Army, the Office of Congressional and Legislative Liaison, and the Office of the Chief of Staff. All Army military personnel records, that is, the Officers' records at Alexandria, VA, are fully converted (one ICS and three Mass Modules); the Enlisted records at Fort Benjamin Harrison, IN, will be fully converted by September 1979 (one ICS and nine Mass Modules). This personnel records conversion was the result of the RAM 2 study group (Records Administration in the Microform Mode). All of the engineering drawings for the Corps of Engineers Rear Echelon Headquarters at Winchester, VA, are stored on a System M. In addition, all of the Marine Corps personnel records at Arlington, VA, and the Coast Guard's active duty records are stored on a System M. Marine Corps Headquarters, Arlington, VA, is installing an ICS with 12 Mass Modules.

3.2 *Inforex System 5000*

Inforex, Inc., of Burlington, MA, is producing an automatic storage and retrieval system that utilizes magnetic disk storage media. The system can store up to 1.2 billion characters or 1200 megabytes of information. The control unit with tape drive can support up to 32 terminals and serial printers. The tape drive keeps the system secure by logging every station transaction with identifying information. Up to eight 25-megabyte disk drives can be connected to one control unit, or four 300-megabyte disk drives, which give the maximum of 1200 megabytes of storage. The terminal station consists of a 15-in. (38-cm) cathode ray tube (CRT) screen displaying 1920 characters of information and a typewriter keypad with a numeric pad and special function keys for data entry and record handling and editing. The maximum access time is 2 s. Optional printers allow hard copy printout at speeds from 30 characters/s to 600 lines/min.

The current price of the control unit is about $40,000, and the maximum storage of four 300-megabyte disk drives is about $200,000. Terminals are about $5000 each. There are 22 systems installed in the Washington, DC, area, 5 of which are in the Pentagon. The front end processing for the Army's RAM 2 system (sect 3.1) is accomplished by an Inforex System 5000. This uses one control unit, one tape drive, one 25-megabyte disk drive, eight CRT terminals, and one 400-line/min printer.

As far as storage of engineering drawings on this type of media is concerned, a typical E-size drawing may be represented by about 2×10^6 bits by using data compression techniques. The maximum storage capacity of this system would thus be 1200 megabytes × 8 bits/byte divided by 2×10^6 bits, or 4800 E-size drawings. The initial cost per drawing is thus about 100 times more with this type of storage system than with microfiche storage. However, depending upon the nature of the program, the versatility of a system such as this could be more valuable and cost effective than mere consideration of storage cost per drawing.

4. NEW TECHNIQUES AND MEMORY DEVICES

Several new memory techniques that promise to further improve the state of the art are now in various stages of development. These include holograms, ovonic memories, magnetic bubble memories, and vesicular film.

4.1 *Holograms*

The holographic image optical technique (sect. 2.4) is being developed by the Harris Co. of Melbourne, FL. It is under development contract to deliver to Rome Air Development Center, NY, a human readable, machine readable (HRMR) system that records holograms digitally on microfiche and reads them back so that the output of the supplied computer (a PDP-11/45) is in American Standard Code for Information Interchange (ASCII). The recording is accomplished by modulating a small air-cooled 15-mW argon laser that emits in the blue region of the spectrum. A second laser is used for readout. This is an air-cooled 10-mW helium-neon laser that emits in the red region of the spectrum. The present capacity is 30 × 10^6 bits per 4 × 6 in. microfiche.

In addition, TRW, Inc., of Redondo Beach, CA, was developing a device to record and read digitized data holographically. The company has not worked on the device in the past year and a half, but it did recently license the device to Holofile Industries of Los Angeles, CA, and delivered two demonstration readers to that company.

The holographic approach has an error rate problem similar to that of the Omex Laser-Optic System (sect. 2.3), that is, a probability of 10^7 versus 10^9 for magnetic tape or disk.

4.2 *Ovonic Memories*

A memory device still in the development stage stems from the amorphous glass semiconductor switch invented about 10 years ago by electronics entrepreneur Stanford Ovshinsky, who founded a small company called Energy Conversion Devices in Troy, MI, to exploit his ideas. Ovshinsky has sold to Burroughs Corp., San Diego, CA, a license to produce the memory device aspect of the invention while he is working on the photographic and energy conversion aspects. The Burroughs Corp. device uses amorphous memory switches in a 256 × 4 array. The circuit acts as a very fast read-only memory (ROM) (read access time is 15 ns) or as a very slow read-write memory (write access time is 15 ms).

The circuit, which is intended to be used as a reprogrammable ROM, can be switched between memory states by current pulses. The switch element uses a phase change as the memory storage mechanism. Each memory cell consists of an ovonic memory switch (OMS) in series with a Schottky diode. The OMS is a layer of chalcogenide glass sandwiched between the first and second layers of chip metallization. The glass, predominantly composed of tellurium and germanium, exists in both amorphous and polycrystalline states. Its resistivity in the amorphous state is about 10^6 times greater than that in the polycrystalline state (about 10^5 ohm-cm versus 0.1 ohm-cm).

Burroughs Corp. is making up specification sheets on the memory devices prior to putting them on the market.

4.3 *Magnetic Bubble Memories*

A new memory device, the magnetic bubble, is being developed by Texas Instruments, Inc., Dallas, TX, and others (including Western Electric Co., Rockwell International, IBM, Hewlett-Packard, Hitachi, Fujitsu, Plessey, and Philips). A magnetic bubble is a cylindrical magnetic domain with a polarization opposite to that of the thin magnetic film in which it is embedded. Bubble memories can be thought of as solid-state integrated analogs of rotating electromechanical memories, such as disk, drums, and tape recorders. In both memories, the information is stored in magnetized regions. In bubble memories, the presence or the absence of the cylindrical domains at specific locations corresponds to binary digits stored at these locations. The domains are moved within the thin magnetic film to an access device, as opposed to physically moving a disk or a tape past an access device. No material is actually transferred in a bubble device; instead, magnetic vectors flip over at successive sites in the film, making the bubble seem to move.

To operate a magnetic bubble memory, four basic functions are required: generation of bubbles, propagation, detection, and annihilation. Bubbles are most commonly generated by means of a current pulse through a hairpin-shaped conductor, called a nucleate generator, which produces a bubble inside the end of the hairpin. Propagation is usually accomplished by means of an external rotating magnetic field. Detection is generally done by using an access device in which the bubbles are stretched into wide strips approximately 400X their diameter and passed over a Permalloy magnetoresistance element. The bubble stretching is analogous to preamplification. A bubble annihilator is commonly combined with a replicator. The replicator stretches the bubble (like the detector), then cuts it in two, sends one piece to the detector where it is read and discarded, and returns the other to the storage area. Also, the bubble can be discarded (annihilated) without return to the storage area.

A magnetic bubble memory system, if organized in a single loop, has the drawback of long access time, similar to a one-track magnetic tape. For this reason, the systems are often organized into multiple loops. A major loop has direct access to the generation, detection, and annihilation devices, and a number of minor loops serve as storage areas for bubbles that can be transferred to the major loop in parallel. The minor loops are analogous to magnetic disk tracks, and the major loops are analogous to a one-track magnetic tape. New information is stored by reversing the transfer procedure.

Two of the projected advantages of magnetic bubble memory systems are (1) the price per bit is low for relatively small capacity (not multimegabits) and (2) in terms of access time versus cost per bit, they fill the gap between conventional solid-state memories and rotating magnetic mass memories.

4.4 *Vesicular Film*

Vesicular photography is a method for the production of photographic images by light and heat alone, without chemical processing. Upon exposure to ultraviolet light, the sensitizer in a vesicular film decomposes and releases nitrogen gas, which is trapped within the plastic layer and constitutes a "latent image." Upon application of heat, the thermoplastic softens and the gas expands to form microscopic bubbles or "vesicles." The vesicular process produces a light-scattering image instead of a light-absorbing one. The advantages of vesicular film are its long life and high resistivity to environmental changes, as well as its ease of development without chemical processing. It has been used for years by Metro-Goldwyn-Mayer for archival copies of movies (limited to black and white only) and by several telephone companies for storage of directory information. In addition, 90 percent of Social Security data is stored on vesicular film. A disadvantage is that it is a slow film that requires exposures to intense ultraviolet light to form the latent image.

The use of vesicular film in microfiche storage and retrieval systems would greatly improve the archival quality of the stored data.

At present, only three companies manufacture vesicular film, namely, the Kalvar Corp. of New Orleans, LA; Xidex of Sunnyvale, CA; and Photomedia Corp. of Sierra Madre, CA.

5. CONCLUSIONS AND RECOMMENDATIONS

The idealized automated storage and retrieval system for engineering documents has not been achieved. Existing systems satisfy some of the requirements with different systems satisfying different areas of the specifications. The best recommendations for the present are as follows: If one wished to store an existing program, a large microfiche system would unquestionably be the least expensive and the best. However, when starting a new program, a magnetic tape or disk system, especially one designed specifically for the creation of engineering drawings, would probably pay for itself because of the ease and the speed of developing and changing the drawings. For a large program, a combination of the two systems would probably be best. As the drawings were developed and became finalized on the magnetic media system, they could be transferred to the microfiche system for the most economical storage. The combination system would also be useful for the often-occurring case of a large program in which, for example, 95 percent of the drawings did not change, but 5 percent were constantly being changed. The 95 percent could be stored on the microfiche system and the 5 percent on the magnetic tape or disk system.

APPENDIX A.—PROPOSED SPECIFICATIONS FOR AN IDEALIZED AUTOMATED STORAGE AND RETRIEVAL SYSTEM FOR ENGINEERING DOCUMENTS

This section is philosophical in that functions are discussed without regard to the factors that contribute to their possible implementation. There are four functional blocks: (1) the input of documents into the system, (2) the update capabilities of the system, (3) the storage capabilities of the system, and (4) the retrieval capabilities of the system.

A-1. SYSTEM INPUTS

Input of documents into the system shall be an automated procedure that couples the input document to the Technical Data/Configuration Management System (TD/CMS) data base and updates the data base as required. Insertion of the physical document into an input station can be a manual process, but the translation of the document into its internal form, whether by electrical or by mechanical transmission, shall be automatic.

If the document undergoes any transformation from its external form to its internal form, then a visual verification of the internal document shall be possible in a rapid manner.

The procedure to verify correct filing and compatibility of the document with the existing TD/CMS indexing structure, for subsequent retrieval requests, shall be automatic and done at the time of document entry.

Any preparation required of the document before it is input at an input station shall be minimal and not cost more than 10 percent of the total cost of inputting the document.

The capability shall exist to automatically reject input documents that are not in proper input format and shall state the reasons why the document was not accepted.

For initial loading of the system and for subsequent major reloading, the system shall have the capability of handling multiple input stations. (The number depends on the speed of the input station and the number of documents being entered.) These input stations shall be readily attachable and detachable so that they can be moved from location to location depending on loading requirements.

A-2. UPDATING CAPABILITIES

Updating shall be a rapid procedure and minimally impact the prime function of the total system, the retrieval of documents. Updating shall closely adhere to the normal input procedures for the system, including automated data entry, filing, and verification.

Where obsolete documents remain in the system after updating, the facility shall exist to automatically purge the system of these documents at a time when storage becomes overcrowded.

Where documents are stored in a form that allows for a structured digital representation to be produced, the capability shall exist to interactively update the document and store the updated document in place of or in addition to the original.

If a document is requested for retrieval while it is in the updating phase, the requestor shall be notified of that fact and given the option to continue or abort retrieval.

Audit trails shall be kept of all updating, and the TD/CMS data base shall be concurrently updated to reflect new revision numbers and their effective dates.

Security shall be provided to insure that only properly authorized updating is entered into the system.

A-3. STORAGE

The storage system shall be modular so that it is easily adaptable to installations with varying storage requirements. An individual system shall be able to expand in handling 200,000 documents at minimum to 2 million documents. Installations requiring storage of more than 2 million documents shall be able to expand to multiple systems.

The storage media shall be of archival quality with a useful life of 20 years and the ability to be transferred at the end of 20 years to other storage media.

The system shall be able to handle documents in different storage media. The type of media in which any document is stored shall be made transparent to the user of the system.

The storage media shall not be vulnerable to electromagnetic pulse (EMP) radiation.

The cost for storing a document in the system, defined as

$$C = \frac{\text{total cost of storage}}{\text{max document capacity}}$$

shall be reasonable, compared with competitive systems.

There shall be no loss of relevant information from the document on passage through the system.

A-4. RETRIEVAL FROM SYSTEM

On a data base of 2 million documents, it shall be possible to concurrently access 100 different drawings from different output stations. For systems containing fewer documents, the number of concurrent accesses shall be linearly proportional to the number of drawings. For example, a 200,000-document system shall require the capability for 10 concurrent accesses.

The access time from the request of a document through the TD/CMS directory system until presentation at an output station shall be less than 5 s for a soft copy output such as a cathode ray tube or a television (TV) display and less than 30 s for a hard copy output such as an aperture card or a full-size paper drawing.

Direct access without going through the TD/CMS computer shall be possible when the user knows the proper access key for the stored document.

Request of an individual document shall not prohibit any document retrieval, including itself, for more than 30 s.

If for any reason a requested document is not delivered to an output station in the prescribed time, the user shall be notified of the reason for the delay. Some of the possible delays are system malfunction, multiple requests for the same document or document group, illegal request, unauthorized request, drawing being updated, drawing not in the system, and TD/CMS directory error.

The production of technical data packages shall be an automated retrieval process that produces a user defined number of collated duplicate technical data packages.

The capability shall exist to request documents over dial-up voice grade telephone lines and have the document data transmitted over such lines and reproduced at the requestor's output terminal in less than 3 min.

There shall be a capability for modular output stations that provide any or all of the following features:

a. Quick-look TV raster terminal that has local zoom and translation control

b. Aperture card reproduction that is visually equivalent to the original document

c. Microfiche reproduction that is visually equivalent to the original document

d. Local digital storage of document and associated graphics terminal that electronically zooms a document with a resolution comparable to the visual resolution of the original document

e. Digital interface to allow a digitized drawing to be transferred to a variety of digital media, including a computer

A-5. TOTAL SYSTEM

In addition to the individual subsystems that make up the total system, there shall also be some characteristics that apply to the system as a whole.

A local process controller shall directly handle retrieval, input, and updating requests or transfer control to and from the TD/CMS computer. This controller shall be fully compatible with the TD/CMS software.

The system shall be maintainable on a service call basis and shall not require continuous on-site maintenance personnel. A reasonable cost for maintainability shall be 1 percent of the equipment purchase price per month and shall cover both preventive and corrective maintenance.

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