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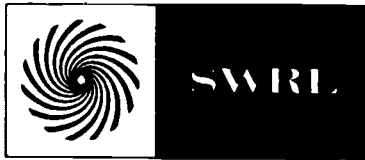
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               Teletypewriters

ABSTRACT
          The operational features of feasible alternative
configurations for a computer-based instructional management system
are identified. Potential alternative means and components of
accomplishing these features are briefly described. Included are
aspects of data collection, data input, data transmission, data
reception, scanning and processing, information/results/materials
transmission and information/results/materials output. A chart
depicts the closed-loop operation. (SK)

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TITLE: IDENTIFICATION AND DESCRIPTION OF ALTERNATIVE MEANS OF
          ACCOMPLISHING IMS OPERATIONAL FEATURES

AUTHOR: Ashok Dave

ABSTRACT

The operational features of feasible alternative configurations for a
computer-based instructional management system are identified
and the potential alternative means and components of accomplishing
these features are briefly described.

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IDENTIFICATION AND DESCRIPTION OF ALTERNATIVE MEANS
OF ACCOMPLISHING IMS OPERATIONAL FEATURES

OPERATIONAL FEATURES OF A REALIZABLE IMS CONFIGURATION

SWRL's Instructional Management System (IMS) is designed to collect individual performance data from schools, to process the data, and to provide useful derivative information to persons responsible for some aspect of the pupil's performance (see TM 5-71-01). The operating features of IMS are:

- collecting and sending pupil performance (and other IMS-relevant) data from school sites to processing centers--data collection, input, and transmission

- receiving, scanning, and processing the data, and developing useful information, results, and materials--data reception, scanning and processing

- storing the data and other pertinent information to assist the processing--data/information/materials storage

- receiving and distributing the processed information, results, and materials at school sites--information/results/materials transmission, output and dissemination

- requesting pupil performance (and other IMS-relevant) information, and maintaining and updating this information from school sites-- query and information/results/materials retrieval

These operating features of IMS are grouped into three basic physical categories, as shown in Figure 1. The structure of the matrix is flexible. If, for example, the processing center were located at the school site, the communications aspect of the matrix could be partially or completely eliminated. In the same example, data scanning could be carried out at

Figure 1. Operational Features--Physical Classification Matrix

PHYSICAL CLASSIFICATION / OPERATIONAL FEATURES	SCHOOL SITE	COMMUNICATIONS	PROCESSING CENTER
Data Collection	X		
Data Input	X		
Data Transmission		X	
Data Reception, Scanning, and Processing			X
Data/Information/Materials Storage			X
Information/Results/Materials Transmission		X	
Information/Results/Materials Output	X		
Information/Results/Materials Dissemination	X		
Query and Information/Results/ Materials Retrieval	X		

,schools, leaving the processing to be done at centers; or, the storage

feature could be at school sites as well. Thus, the basic idea behind

the matrix is to show that certain operating features of IMS can be

conveniently and functionally grouped together. The essential means

for carrying out (manually, automatically, or in combination) these

features can be classified on a geographical location basis. Figure 2

depicts the closed-loop operation of IMS.

POTENTIAL MEANS OF ACCOMPLISHING IMS OPERATIONAL FEATURES

DATA COLLECTION

This feature concerns the collection of data from the originating

sources (e.g., test sheets from pupils). This can be performed in a

variety of ways.

Designated Person Collects and Hand-Carries

After each student has marked the test sheet, a designated person

collects the sheets from all the sources and hand-carries them in a

batch mode to an input device or some other location.

Each Student Hand-Carries

Each student, after completing the test, hand-carries his test

either to the input device or some other location where all the sheets

are deposited.

Transport Mechanism

A mechanism, such as a conveyor belt or chute, can be used to

transport test sheets from the originating sources to a central loca-

tion or into the input device.

Figure 2. Closed-Loop Operation of IMS

Storage

Data Processing

Data Reception

Data Transmission

Data Input

Data Collection

Administrators,
Teachers,
Parents,
Pupils,
Others

Information/Results/Materials Transmission

Information/Results/Materials Output

Information/Results/Materials Dissemination
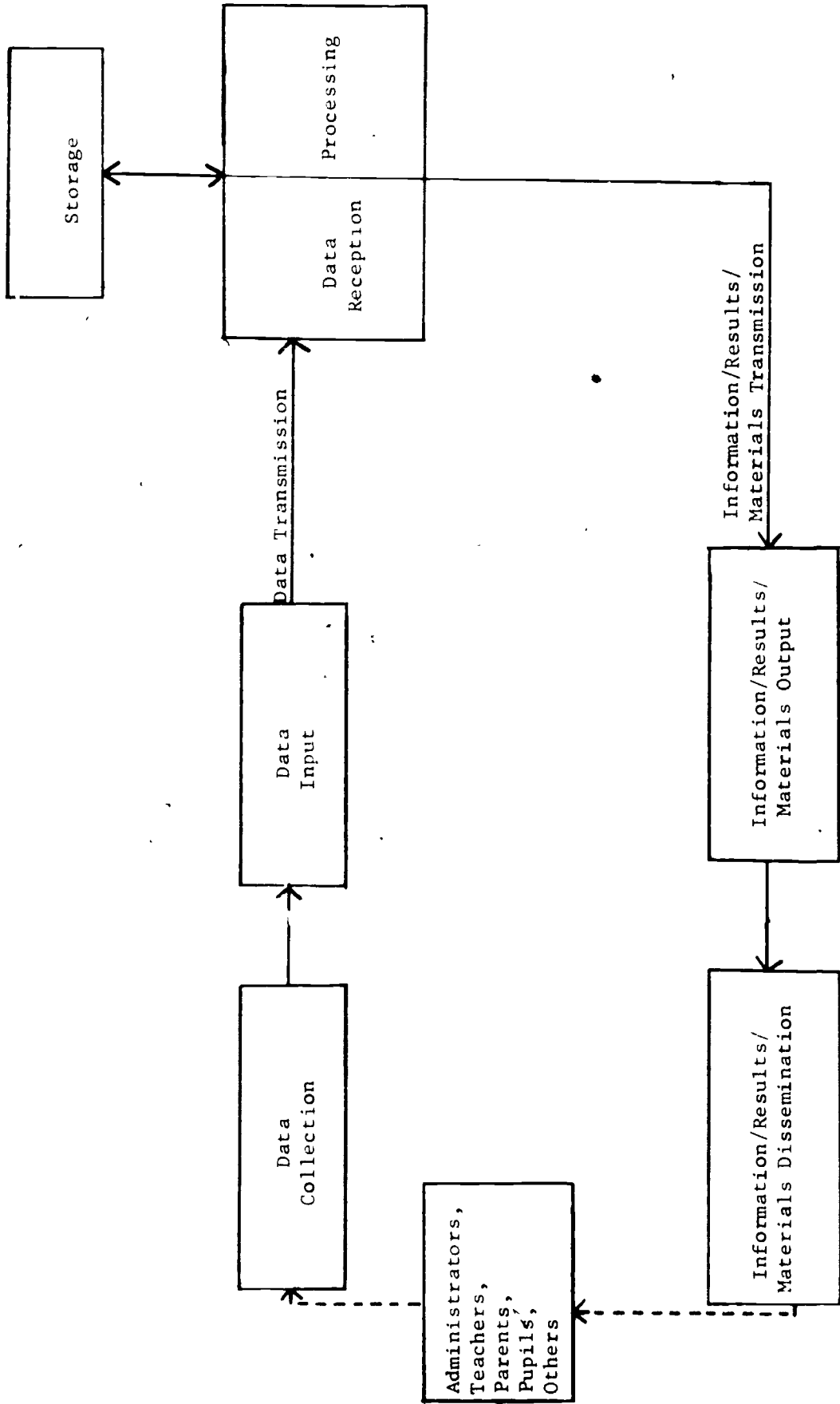
On-Line Interaction

Each student interacts on-line with an input device (thereby eliminating the data collection feature).

DATA INPUT

Data entered at the input device can be transferred onto an intermediate storage medium—as shown in the matrix (Fig. 3). It can then be transmitted over communications lines from any of these media. Therefore, the data entered from a teletypewriter or a CRT (cathode ray tube) device can be recorded onto a paper tape or magnetic tape (e.g., cassette, cartridge). Touch-tone terminals transmit analog audio signals which can be digitized and stored on a magnetic tape. The optical devices generate data-related codes which can be transferred to paper or magnetic tape. Plastic card readers are commonly used for the verification of credit cards. The punched card reader transmits the position of holes in the card in a computer readable form. Battery operable portable data terminals work on the same principle as that of a standard teletypewriter, with the exception, and as the name suggests, that they are portable and can be operated on rechargeable batteries. Human voice input devices, now under development, will enable the user to input data by means of natural or artificial speech. A brief description of these data input devices is given below.

Teletypewriter

A teletypewriter is an electromechanical device that provides facilities for exchanging data and information via appropriate transmission facilities. This device can be either:

Figure 3. Input Devices and Related Intermediate Storage Media

ONTO FROM Data Input Device*	OUTPUT MEDIUM(S)			
	Paper Tape	Cards	Magnetic Tape	Hard-Copy**
Teletypewriter	X	X	X	X
CRT	X	X	X	X
Touch-Tone Terminal			X	
Optical Mark Reader	X	X	X	
Optical Character Reader	X	X	X	
Plastic Card Reader			X	
Punched Card Reader		X		
Battery Operable Portable Data Terminal	X	X	X	X
Human Voice Input Device			X	

* An input device is generally referred to as a source data input device when it directly captures data for computer processing at the originating source without human intervention with the data. This procedure is generally referred to as Source Data Automation (SDA).

** Hard-copy options extend verification and editing (if required) of raw data.

- a receive only (RO) unit

- or a send and receive unit.

The receive only type does not have a complete alpha/numeric keyboard, and only has a mechanism for receiving and printing the information. The send and receive unit can either be a keyboard send-receive (KSR) or an automatic send-receive (ASR) teletypewriter. The KSR provides facilities for originating messages for transmission by the manual operation of a keyboard, and for receiving and printing messages; the ASR has the added facility of transmitting by the reading of a perforated paper tape, and to receive messages and perforate them on tape.

CRT

A cathode ray tube is similar in construction and appearance to the picture tube of monochrome television sets. A light pen or a keboard permits the user to input the data via a CRT terminal, which can either be stored on a paper/magnetic tape and/or transmitted to the computer.

Touch-Tone Terminal

Touch-tone terminals, whether numeric or alpha/numeric, consist of a keyboard. Each key on the keyboard sends a different audible signal. Special equipment at the receiving center is required to receive the series of tones for interpretation, storage, and processing by the computer.

Optical Mark Reader

An optical mark reader reads marks that have been entered on a form in a prescribed location, reads them, and can either transmit the mark

or store it on tape or punch card. In addition to these functions, this type of device can also score, and print limited information on the forms at the input location (see TN 5-71-86 and TN 5-71-90 for further discussion of optical mark readers).

Optical Character Reader

These readers recognize the characters by their pattern, and some of the readers can read hand-printed alpha/numeric data.

Plastic Card Reader

This is an electronic device used to verify plastic credit cards by an on-line link to a computer. The methods of recording data on plastic cards for eventual transference to a computer can be magnetic striping, optical character recognition, punched holes, color bars, or fluorescent sensitivity.

Punched Card Reader

The data to be processed can be key-punched on cards and a card reader can then transmit the data to the computer.

Battery Operable Portable Data Terminal

These terminals are portable and are operable on batteries. Data are entered by depressing the appropriate keys on the keyboard, and the keyed data are automatically recorded on the magnetic tape. A strip printer for printing the data completes this portable terminal configuration.

Human Voice Input Device

A simple illustration of such a device is the ordinary telephone. However, a sophisticated automatic speech synthesis and recognition mechanism is required at the computer end to accept this mode of input. .

DATA TRANSMISSION*

This IMS feature is comprised of sending the data which is collected at school to the processing center, which could either be accomplished manually or in an automated mode. Various potential means of accomplishing this feature are described below.

Courier Mail

Data are carried from one place to another by a courier (who can either walk or use a vehicle).

U.S. Mail

The United States postal facilities can be used for transmitting the data to the processing center.

Telephone Lines

The telephone communications lines** are utilized in different ways to transmit data, and depending upon this mode of data transmission,

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*Much of the discussion in this section is based on information presented in Telecommunications and the Computer by James Martin, Prentice-Hall, 1969.

**Communications lines fall into one of three categories of speed (Martin, 1969):

1. Narrow-Band: Lines designed for telegraph and similar machines transmitting at speeds ranging, in the U.S., from 45-150 bps.

2. Voice-Band: Telephone channels normally transmitting today at speeds from 600-2400 bps. Speeds up to 4800 are in use ....speeds of 7200 and possibly higher can be expected in the near future.

3. Wideband: Lines giving speeds much higher than voice channels, using facilities which carry many simultaneous telephone calls. Speeds up to about 500,000 bps are in use, and higher bit rates are possible if required.

they are assigned specific service-names. There are two basically
different types of service that the Common Carriers (mainly The Ameri-
can Telephone and Telegraph Company--AT&T, the Bell System, General
Telephone and Electronics--GT&E, and Western Union Telegraph Company)
offer. One is the public or exchange service which consists of sub-
scriber lines connected to a switching system, as the telephone network.
The other is the private line or channel leasing service which consists
of full-time leased point-to-point or multipoint lines connecting
locations belonging to only one customer. The cost of the exchange
service usually consists of toll charges based on the distance and
length of connection, and a monthly service charge. The cost of private
line service consists of a monthly rental based on the length and type of
line. Different services offered by the Common Carriers which provide
communication with or without modems are briefly described below.

WATS. The Wide Area Telephone Service permits a subscriber to
place calls within a specified area at a flat rate. Monthly charges
are based on the radius or area covered and not on the number or length
of calls.

TELPAK. This is a private line, "bulk" communications service
offered in the U.S. by the telephone companies and Western Union. It
transmits high-volume point-to-point communications in various forms--
voice, telephotograph, teletypewriter, control, signaling facsimile
and data. It can be tailored to provide wideband communications also.

To lower the cost of network of communications lines, it is often desirable
to attach more than one terminal, or more than one concentrator, to a
single leased line. A line such as this with several "drop-off" points is
termed a multidrop line. When several devices all share a communication
line, only one can transmit at once, though several or all points can
receive the same information.

. TWX and TELEX. These are the names applied to the teletypewriter
exchange services of the Bell System and the Western Union respectively.
They provide direct dial point-to-point connections using input/output
equipment such as printers, punches, read'''', and keyboards.

DATA-PHONE. Through the use of   -, the DATA-PHONE provides
for the transmission of data using the regular dial-up telephone net-
.work. The same network can also be used for local and long-distance
voice communication.

DATA-PHONE 50. Bell System provides this switched wideband data
communications service. A subscriber can dial a call and send data
at speeds up to 50,000 bps, a 25 fold increase over the "voice-band"
DATA-PHONE service.

INFO-COM. Developed by Western Union, INFO-COM is a store-and-
forward message or data communications service.

DIAL-PAK. A part of Western Union service, it extends direct
computer-to-computer communications using a 48 kHz wideband switched
system.

Private-Line Voice Service. This service provides a private
voice-grade line for the exclusive use of a particular subscriber.
It can be used for either voice communication or data transmission
using a modem. The charges for this service are based on a per mile,
per month basis.

Telegraph Lines

These lines are separate from the voice-grade network and
accommodate speeds from 45 to 150 bps. A DC current modulation
technique is usually used to transmit data.

Coaxial Cable

The coaxial cable consists of a hollow copper cylinder, or other cylindrical conductor, surrounding a single wire conductor. A very large number of separate telephone calls can be transmitted together through a coaxial cable system.

Microwave Radio

Like coaxial cable, microwave links can carry thousands of voice channels, and are widely used for the transmission of television. Since these waves require line-of-sight transmission, the antennas which relay them must be at points high enough to be within sight of one another. Privately owned microwave links have also been set up by some corporations.

Satellites

A communications satellite provides a form of microwave relay. Its location in space allows it to relay signals over long distances that would not be possible in a single link on Earth (because of curvature, mountains, and atmospheric conditions). The satellites are powered by solar batteries. Like microwave links on Earth, they can be built to handle several thousand voice channels. It is likely that in the 1970s they will be used as an alternative to the other media discussed for long distance traffic within a country such as the U.S.

Tropospheric Scatter Circuits

Since the troposphere scatters radio waves, it is used for telecommunication links of up to about 600 miles. They utilize very large antennas and a higher transmitter power than microwave circuits. Of the

three--coaxial cables, microwave relays, and tropospheric scatter circuits--microwave relay is the least expensive.

Short-Distance Radio

It is possible that short-distance radio links of the type used in taxis and walkie-talkies will be widely used for computer input and output. A small mobile radio terminal may work in conjunction with a transmitter on a device which is connected to a computer by land line. It may also operate with the public mobile telephone service for vehicles.

Waveguides

A waveguide is a metal tube through which radio waves of very high frequency travel. It is presently under development, but is not used for long-distance communication; it is rarely employed for distances over a few thousand feet. The waveguide, constructed by Bell Laboratories, is capable of carrying no less than 200,000 voice channels in one direction. This system, when operational, will be excellent for data transmission.

Lasers

Operating at the frequency of light, lasers have been successfully used to transmit data from space vehicles. Presently, they are still mostly in the realm of research laboratories for earthbound communications. It seems probable, however, that they will eventually provide the means of building channels of enormous capacity. It has been said that lasers portend a revolution in telecommunications as fundamental as the invention of radio. Lasers of many different frequencies could travel together down the same fiber, and a bundle of such fibers could

occupy one pipe. Such a laser system has the potential ability to carry
all the information carried by all of the telephone lines in the world
today at the same time!

DATA RECEPTION, SCANNING, AND PROCESSING

This IMS feature is accomplished by using computers.* There are a
number of ways to describe and differentiate amongst computers. Aside
from cost, internal core memory size, memory cycle time, and word length
and structure are perhaps the most distinguishing characteristics of a
computer.

The size of internal core memory is a major factor in the computing
power of the central processing unit (CPU). The memory is usually
organized into words, bytes, or characters which have a fixed length.

Memory cycle timing determines the speed of the computing operations.
Cycle time is generally defined as the period of time required for a
memory to go through a complete read-write cycle and be prepared to
begin the next cycle. The read access time is also an important
feature of the memory characteristics. It is the time required for
the information output lines from a memory to become stable after the
read portion of a read memory cycle.

Memory word size refers to the number of binary digits (bits) that
can be retrieved from or stored in the internal memory in a fixed time

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*In instances where manual modes (e.g., mail) of data transmission are
employed, the reception of data at the processing site would require sys-
tematized procedures of receiving, coding, and preparing the data for
further processing. Orderly means of filing and documenting would also
be important considerations.

interval (usually the memory cycle time). The word size determines the accuracy and efficiency of processing operations.

For IMS purposes, alternative computers will be characterized in three dimensions; on the basis of internal core memory size--expressed in K's (thousands) of words; on the basis of word size--in bits per word; and on the basis of the cost of the computer with the CPU and basic memory--expressed in dollars. According to these three dimensions computers have been classified as mini-computers, midi-computers, and large-computers in the following table (Fig. 4).

Figure 4. Classification of Computers

	INTERNAL CORE MEMORY SIZE (K-words)	WORD SIZE (bits/word)	COST OF CPU & BASIC MEMORY ($)
LARGE	> 64	> 24	> 100,000
MIDI	⩽ 64	⩽ 24	⩽ 100,000
MINI	⩽ 32	⩽ 16	⩽ 40,000

The figures in this table have been derived from recent literature and discussions with knowledgeable persons in this field. Since the cost-capability ratio of computers is increasing at a rapid rate, the

classification base may well be transitory. If so, the direction
will inevitably be a downward movement of the first two columns.

DATA/INFORMATION/MATERIALS STORAGE

Storage for IMS data/information/materials can either be an exact
copy or a digital medium. Exact copy storage consist of the storage of
one or more copies of the original record or document itself (e.g., carbon
or duplicated copies in files, bound volumes of printed pages, etc.).
With respect to problems of document miniaturization for more compact
exact copy reproducible storage, optical memories (e.g., roll microfilm
or microfiche) are frequently used. Another approach to document min-
iaturization with exact copy reproduction capabilities involves the use
of video tape.

Digital storage of data entails digitalization, compaction, and
recording of data on some medium. Alternative digital storage media
are briefly described below.

Magnetic Drum

The memory element for the magnetic drum is a cylinder with a
magnetizable external surface on which data can be read or written by
magnetic recording techniques. In the fixed head version, the heads
are fixed in the drum, providing one head for each track. In moveable-
head drums, one read/write head exists for a group of tracks and all the
heads are moved by a mechanical positioner. Drum memories are built-in,
i.e., are non-removable from the computer system.

Magnetic Disk

The magnetic disk is a flat, circular plate with one or both
magnetizable surfaces which rotate about the axis perpendicular to the

centers of its flat sides. More than one disk can be stacked along this axis and rotate on a common shaft. The read/write head(s) may either be fixed or moveable. When the disks are non-removable, they are known as disk drives or disks. Removable disks are generally known as disk-pac₁ᶜ or disk-cartridges.

Magnetic Card

Data may be stored by selective magnetization of the surface of this card. The card is usually made of flexible plastic material with a coated surface on one side on which data may be stored in tracks. Magnetic card memories are usually removable-media, since the card stack can be easily changed.

Magnetic Tape

The storage here is on a loop of magnetic tape that is driven past a read/write head for information retrieval/data recording. Many loops form a cartridge, and there can be one or more read/write heads per loop, positionable across the tape. The cartridge is usually removable.

Punched Card

By means of holes punched in a card, data are fed into the computer. These cards also serve as a storage medium.

Punched Tape

This is a paper or plastic ribbon having one longitudinal row of small feed holes and a number of rows of larger data processing holes. As with the punched cards, data, once recorded, is permanent and cannot be erased.

Optical Memories

A variety of optical storage media using film, cards, or chips are presently available. The data stored on these are digitized and compacted.

However, similar to punched card and tape, data, once recorded, cannot

be changed, i.e., they are non-rewritable read-only memories.

Core Memory

An integral part of the computer, core memory is composed of

ferrite core, bi-polar, or semi-conductor (metal oxide semiconductor,

usually abbreviated as MOS) memory arrays.

Figure 5 provides an overview of the above-discussed storage media.

Figure 5. Overview of Storage Media and Techniques

STORAGE MEDIUM	STORAGE TECHNIQUE			
	Exact Copy		Digital	
	Readable	Rewritable	Readable	Rewritable
Carbon Copy	X			
Duplicated Copy	X			
Printed Copy	X			
Optical Memories	X		X	
Magnetic Tape			X	X
Magnetic Drum			X	X
Magnetic Disk			X	X
Magnetic Card			X	X
Punched Card			X	
Punched Tape			X	
Core Memory			X	X

INFORMATION/RESULTS/MATERIALS TRANSMISSION

Transmission of IMS information and results to intended persons can either be accomplished manually* or in an automated mode. The same various potential means of accomplishing this feature, previously discussed in the section DATA TRANSMISSION, can be applied here.

INFORMATION/RESULTS/MATERIALS OUTPUT

This section describes the potential means by which IMS information, results, and materials can be received and generated in a form readable and understandable to the intended persons. Some of the devices that can accomplish this feature have been discussed previously in the DATA INPUT section (viz., Teletypewriter and CRT). Other devices and techniques are briefly described below.

COM

This acronym stands for Computer Output Microfilm. Information in the form of microforms is produced at the receiving end in this case. However, a microform reader is required to enable the user to read the information on the microform.

Printer

The printer is a receive only (RO) type of teletypewriter which prints the information on paper. Printers with wider carriages than teletypewriters are usually known as Line Printers.

The Computer Forms Printer (CFP) developed by Xerox Corporation transforms standard 11" x 14 7/8" computer printout into 8½" x 11" format. Also, by the use of a simple forms overlay inserted into the

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*Where manual modes of transmission are employed, proper methods and procedures for coding, filing, and transmitting (e.g., mailing) the relevant information need special planning and attention.

CFP, special headings, columnar delineations, graphics, and other constant alphanumeric information can be added to each reduced copy (e.g., printing of student identification data on tests; insertion of graphics and columnar delineations in IMS reports; etc.).

Telecopier

Accepting transmission of pictures, maps, diagrams, etc., via facsimile (FAX), the telecopier at the receiving end duplicates this information on some form of paper.

Computer Synthesized Voice

Computer synthesized voice can be heard, in the simplest form, via an ordinary telephone. Such systems at the computer end are generally known as voice response systems (VRS) and can transmit computer-composed messages in spoken language (see TN 5-71-45 for a description of voice response systems).

INFORMATION/RESULTS/MATERIALS DISSEMINATION

IMS information, results, and materials can be disseminated to the intended persons either manually or in an automated mode. For manual dissemination, the information can either be distributed to the intended persons or the end users themselves can collect the information from a central location. In an automated mode, the end users receive the information on an on-line interactive basis with the input/output device, and the dissemination feature is thus eliminated.

QUERY AND INFORMATION/RESULTS/MATERIALS RETRIEVAL

Depending on the type of device and the method of operation, the query can either be on-line in an interactive mode, or in a batch mode.

Any of the data input devices discussed in the section, DATA INPUT, can be used to query an information bank. Other mechanisms for querying from a remote site are described briefly:

Facsimile Transmitter

A query or retrieval request, once written (or typed) on a sheet of paper, can be transmitted by the use of a facsimile transmitter. The request will be reconstructed and duplicated on a telecopier at the other end.

Handwriting Transmitter

This device enables the user to write something on a roll of paper attached to the transmitter, and simulatneously the same handwriting is reproduced at the other end on a similar machine via an ordinary telephone communication link.

Utilization of either of these devices necessitates a manual interpretation of the request at the computer end.