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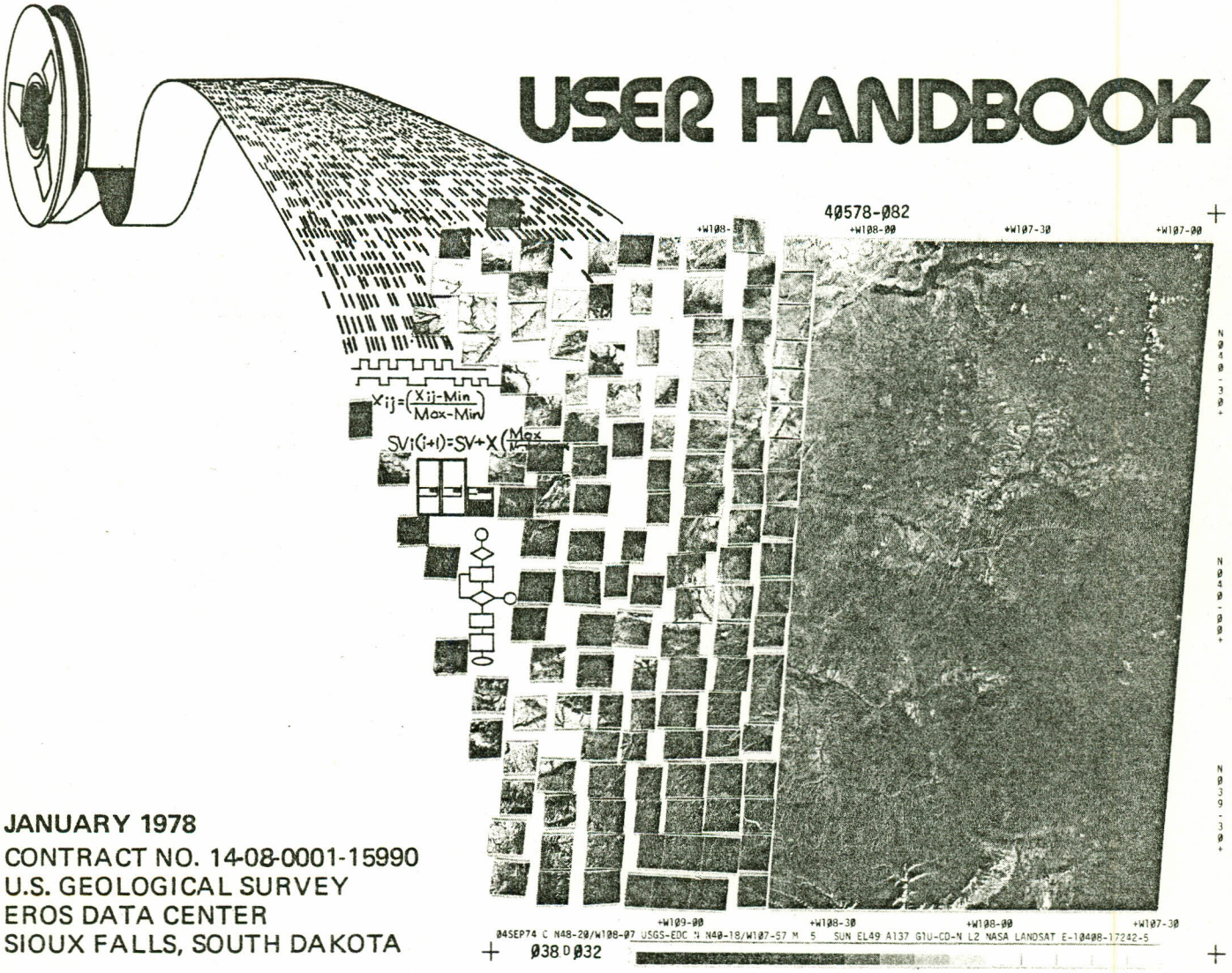
EROS DIGITAL IMAGE PROCESSING SYSTEM



USER HANDBOOK

JANUARY 1978

CONTRACT NO. 14-08-0001-15990
U.S. GEOLOGICAL SURVEY
EROS DATA CENTER
SIOUX FALLS, SOUTH DAKOTA

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30400-6009-RU-00

EROS DIGITAL IMAGE PROCESSING SYSTEM

USER HANDBOOK

PREPARED BY TRW/DSSG

FOR

U.S. GEOLOGICAL SURVEY

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SECTION I

INTRODUCTION

The EROS Digital Image Processing System (or EDIPS) is an integrated, highly automated, data processing system. EDIPS is used by the U.S. Geological Survey at its EROS Data Center (Sioux Falls, South Dakota) for processing LANDSAT data and generating film and magnetic tape products that are distributed or archived.

This handbook describes the EDIPS operating system: the hardware, software, and interface elements; the inputs, thruputs, and outputs; the data flow, algorithms, and types of computations; and the interaction of hardware, software, and computer operator personnel.

1-1. SCOPE

The handbook is divided into five sections. Section I summarizes the major EDIPS functions, indicates the inputs (source/type/format) and products generated, and provides a brief list of related documents. Section II describes the EDIPS hardware and software elements and their individual functions in the operating system. Section III provides a general description of the data flow, processing modes, and man/machine functions. Section IV discusses the design and use of EDIPS. Section V provides user application information. An appendix provides descriptions of the EDIPS software modules.

1-2. EDIPS INPUTS

EDIPS provides the final processing of digital images from the LANDSAT series (1, 2, and C) of satellites (refer to Figure 1-1). These satellites continuously orbit the Earth and scan its surface with Multispectral Scanning Radiometer and Return Beam Vidicon sensors. The sensor data are transmitted to NASA's Goddard Space Flight Center in Greenbelt, Maryland where they are formatted onto High Density Tapes (HDTs) in a digital format. These magnetic tapes, containing 20,000 bits per inch of formatted digital images, serve as the primary input medium for EDIPS.

a. LANDSAT Sensor Image Data

All three LANDSAT satellites (1, 2, C) generate Multispectral Radiometer (MSS) data; in addition, the LANDSAT C generates Return Beam Vidicon (RBV) data. The MSS generates a continuous swath of data 115 miles (185 km) wide. At NASA/GSFC these data are formatted into scenes 115 x 115 miles square. The RBV sensors in LANDSAT C cover approximately the same area, but divide it into four roughly equal quadrants that are recorded sequentially. These RBV quadrants are called subscenes.

LANDSAT 1 and 2 MSS data contains four sequential bands (4-7) per scene; LANDSAT C data contains five sequential bands (4-8) per scene. Table 1-1 summarizes the LANDSAT sensor capabilities.

Table 1-1. LANDSAT Sensor Capabilities

LANDSAT Satellite	Sensor Type	Spectral Bands Covered/Scene	Image Recorded During	Spectral Band Coverage
1,2	MSS	4,5,6,7	Daytime	Visible and near IR
C	MSS	4,5,6,7,8	Daytime	Visible and near IR and thermal IR
	MSS	8	Nighttime	Thermal IR
	RBV	-	Daytime	Visible

b. High Density Tapes (HDTs)

The HDTs received and processed at the EROS Data Center are either Type A or Type P. The Type A tapes (HDT_A) contain image data that have been corrected for system radiometric anomalies only. No geometric correction has been done. In contrast, the Type P tapes (HDT_P) contain image data that has been corrected for both radiometric and geometric anomalies.

Each HDT contains digital image data from only one type sensor (MSS or RBV), and from only one satellite. The scenes on a single HDT are sequential and contiguous. Each HDT will typically contain 38 MSS scenes with five spectral bands per scene, or up to 72 RBV subscenes.

1-3. MAJOR EDIPS FUNCTIONS

The EDIPS system performs three major functions:

a. Accepts HDT magnetic tapes from NASA/GSFC and performs automatic or selected image enhancement functions to the image data on the tapes.

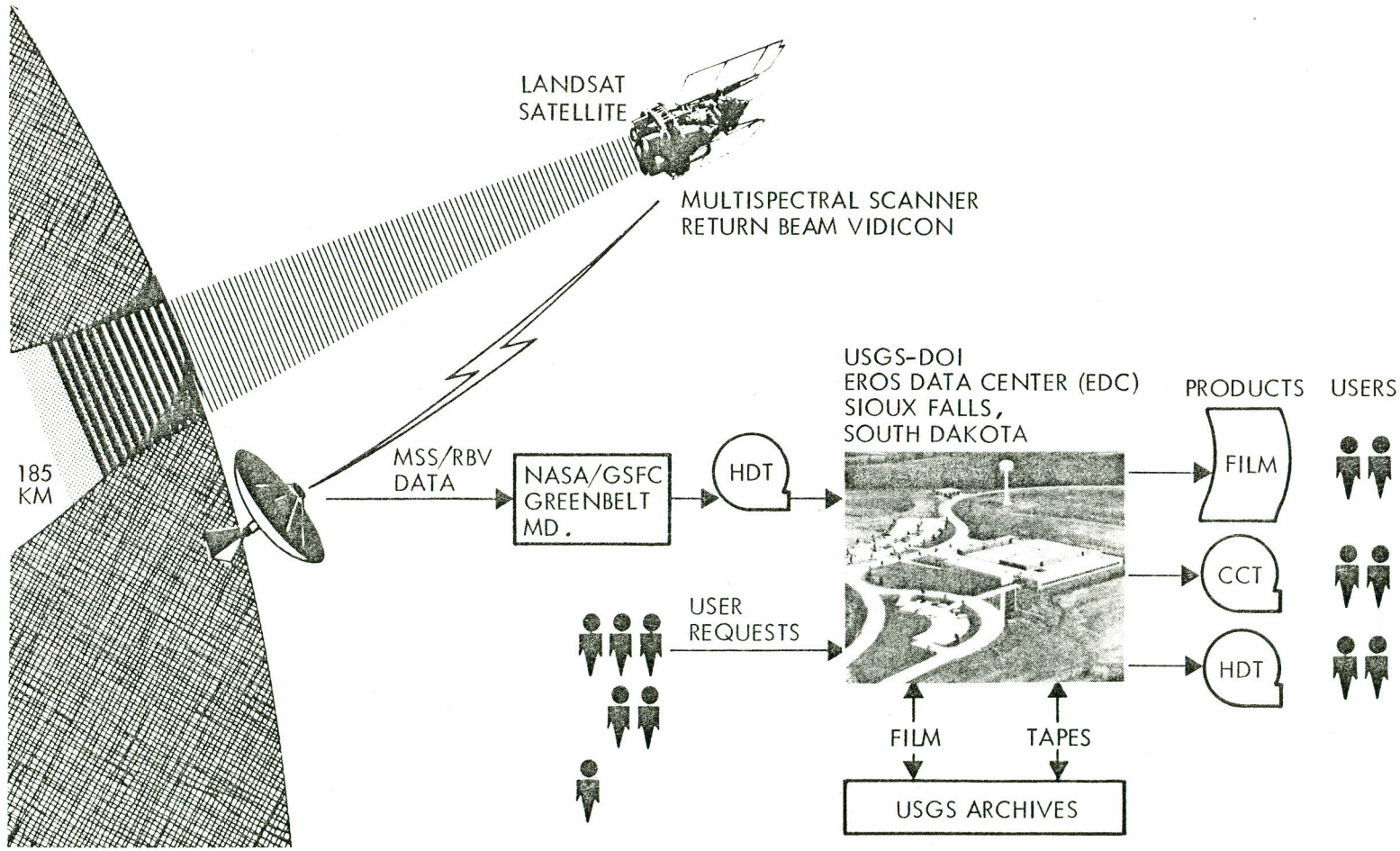


Figure 1-1. LANDSAT Data Inputs to EDIPS

b. Outputs data in the form of first generation film imagery from radiometrically and geometrically corrected tapes (HDT_P).

c. Outputs data in the form of computer compatible tapes of various formats and contents.

In addition to these three primary functions, EDIPS also copies HDTs or computer compatible tapes (CCTs), and produces film products from CCTs containing radiometrically corrected data (Type A).

The operation of the EDIPS system in performing each of these functions is described in later sections of this handbook.

1-4. EDIPS IMAGE ENHANCEMENT

EDIPS has the capability to automatically adjust the overall and specific characteristics of image data and thereby recover sensor data that is located in saturated or under-saturated regions. This process is known as Contrast Stretch. EDIPS also has the ability to correct image data for atmospheric scattering effects (Haze Removal), and can also perform high frequency edge enhancement to improve the visibility of fine structure in an image. These image enhancement capabilities are further described below. Figure 1-2 illustrates typical MSS scenes, showing unenhanced and enhanced views of the same scene.

a. Contrast Stretch

The digital data on the received HDT is linearily stretched such that areas of saturated data can be contrast adjusted to best fit the digital count range of radiance. The maximum range is 0-255.

b. Haze Removal

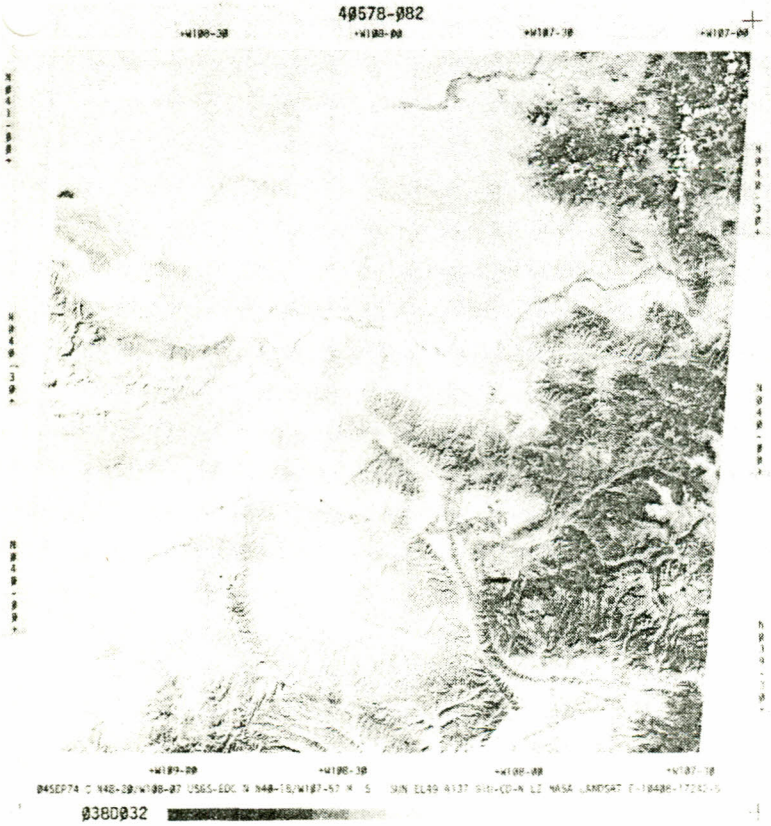
To correct image data for atmospheric scattering effects, a fixed radiance bias commonly referred to as "scatter" or "haze" may be removed from each-MSS spectral band or RBV subscene.

c. High Frequency Edge Enhancement

An optional high frequency edge enhancement algorithm incorporated in the EDIPS system improves the visibility of fine structures in an image by implementing spatial filters during image processing. These filters boost the proportional contributions of high frequency spatial variations in the output imagery and highlight fine structures.

UNENHANCED IMAGE

THE FIGURE BELOW IS A BLACK AND WHITE PRINT OF A TYPICAL MSS SCENE (REDUCED APPROXIMATELY 50% FROM THE ORIGINAL); THE IMAGE HAS BEEN RADIOMETRICALLY AND GEOMETRICALLY CORRECTED, BUT HAS NOT BEEN ENHANCED.



HAZE REMOVAL

THE FIGURE BELOW ILLUSTRATES A TYPICAL MSS SCENE THAT HAS HAD THE HAZE REMOVAL FUNCTION IMPLEMENTED DURING PROCESSING

THE HAZE REMOVAL ALGORITHM IS:

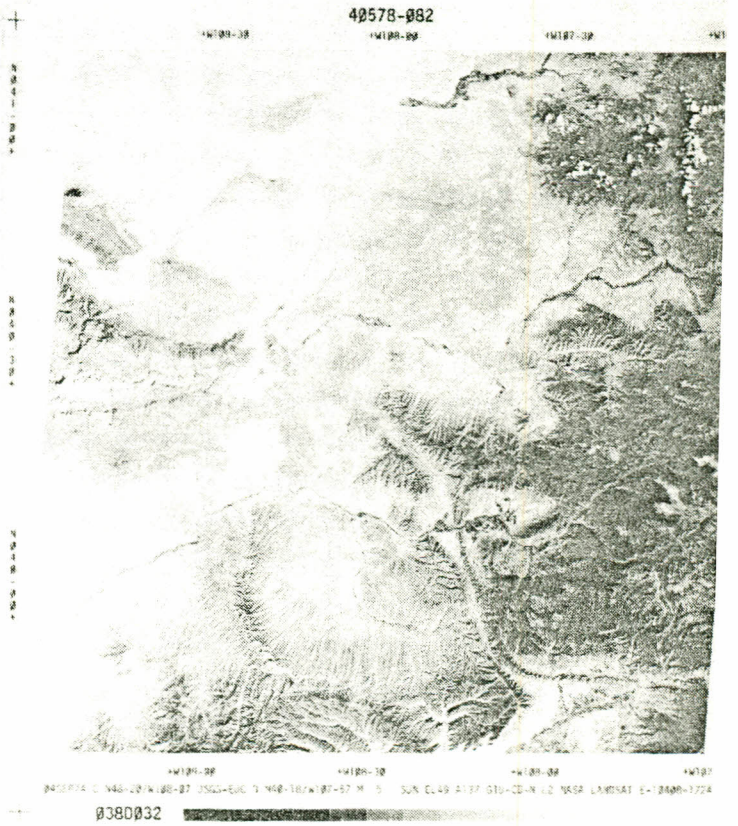
$$Y_{ij} = X_{ij} - \text{BIAS}$$

WHERE:

Y_{ij} = ENHANCED PIXEL VALUE

X_{ij} = INPUT PIXEL VALUE FOR LINE i AND SAMPLE j

BIAS = AMOUNT OF OFFSET FOR EACH SPECTRAL BAND (I.E., BIAS = MIN)



CONTRAST STRETCH

THE FIGURE BELOW ILLUSTRATES A TYPICAL MSS SCENE THAT HAS HAD THE CONTRAST STRETCH FUNCTION IMPLEMENTED DURING EDIPS PROCESSING.

THE CONTRAST STRETCH ALGORITHM IS:

$$Y_{ij} = \left(\frac{X_{ij} - MIN}{MAX - MIN}\right) \times C$$

WHERE:

Y_{ij} = ENHANCED PIXEL VALUE

X_{ij} = INPUT PIXEL VALUE FOR LINE i AND SAMPLE j

[MIN, MAX], A SUBSET OF [0,255], REPRESENTING THE RANGE OF MIN - MAX BRIGHTNESS OF A PARTICULAR SCENE

C = NOMINAL VALUE OF 127

HIGH FREQUENCY EDGE ENHANCEMENT

THE FIGURE BELOW ILLUSTRATES A TYPICAL MSS SCENE THAT HAS HAD THE HIGH FREQUENCY EDGE ENHANCEMENT FUNCTION IMPLEMENTED DURING EDIPS PROCESSING.

THE HIGH FREQUENCY EDGE ENHANCEMENT ALGORITHM IS:

$$Y_{ij} = X_{ij} + C(X_{ij} - \bar{X}_{ij})$$

WHERE:

Y_{ij} = ENHANCED PIXEL VALUE

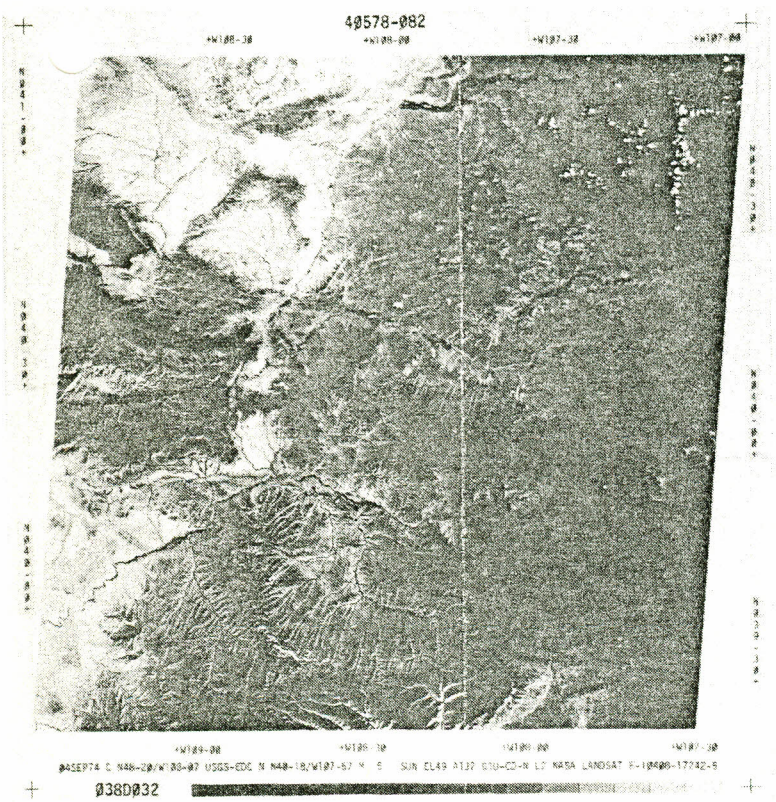
X_{ij} = INPUT PIXEL VALUE FOR LINE i AND SAMPLE j

$\bar{X}_{ij}$ = LOCAL AVERAGE OF LOCATION i, j FROM BOX FILTER

$$\bar{X}_{ij} = \frac{1}{NM} = \sum_{P = i - \frac{M-1}{2}}^{i + \frac{M-1}{2}} \sum_{r = j - \frac{N-1}{2}}^{j + \frac{N-1}{2}}$$

FOR A BOX FILTER OF M LINES BY N PIXELS THE RANGE OF N AN IS BETWEEN 1 AND 9 AND IS ODD.

C = A CONSTANT WHICH CONTROLS THE AMOUNT OF ENHANCEMENT



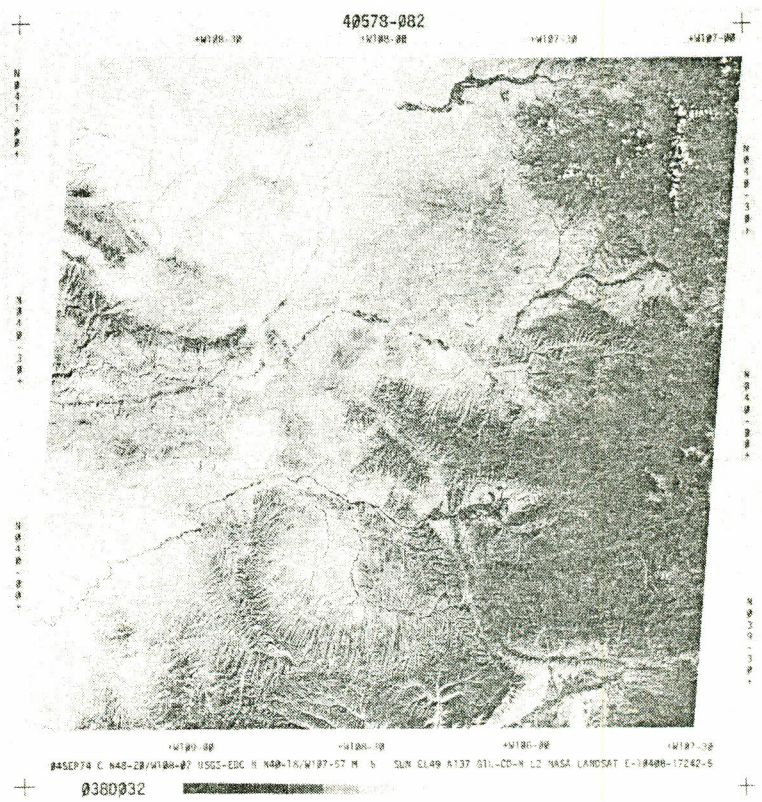


Figure 1-2. EDIPS Image Enhancement

1-5. EDIPS SYSTEM AND PROCESSING MODES

Figure 1-3 is a simplified block diagram of the EDIPS system. A SEL 32/55 minicomputer system controls all processing functions. Six 80-Megabyte disk units provide storage for system software and for image units (MSS or RBV scenes). An array processor is used for high frequency edge enhancement functions. A laser beam film recorder produces film transparencies under control of EDIPS software. Operator input/output terminals are provided to permit necessary operator interaction with EDIPS. Detailed descriptions of EDIPS hardware are provided in Section II of this handbook.

Control of EDIPS system operation resides in the 36 software modules that were developed for the system. As shown in Figure 1-4, these modules are organized in two major categories: Operating and Support Subsystem software, and Image Processing Subsystem software. EDIPS also uses software supplied by the manufacturers for the SEL 32/55 minicomputer and the array processor. EDIPS software is more fully described in Sections II and III.

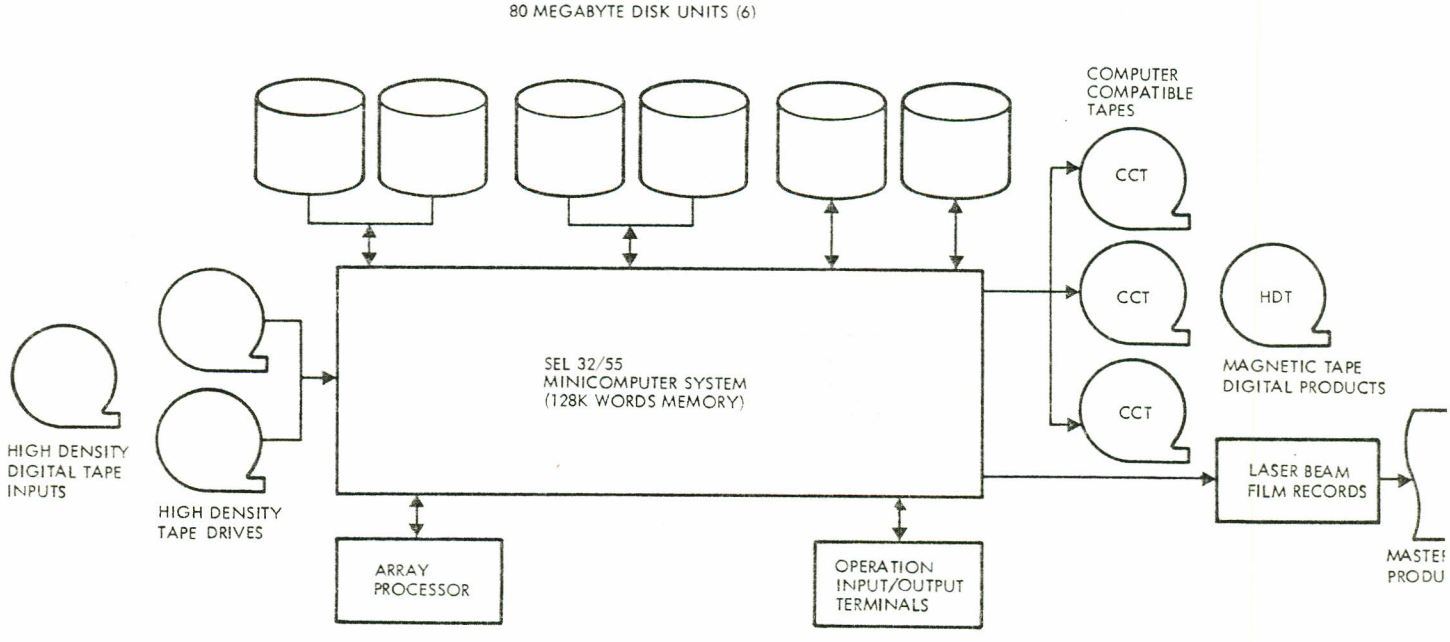


Figure 1-3. EDIPS Simplified Block Diagram

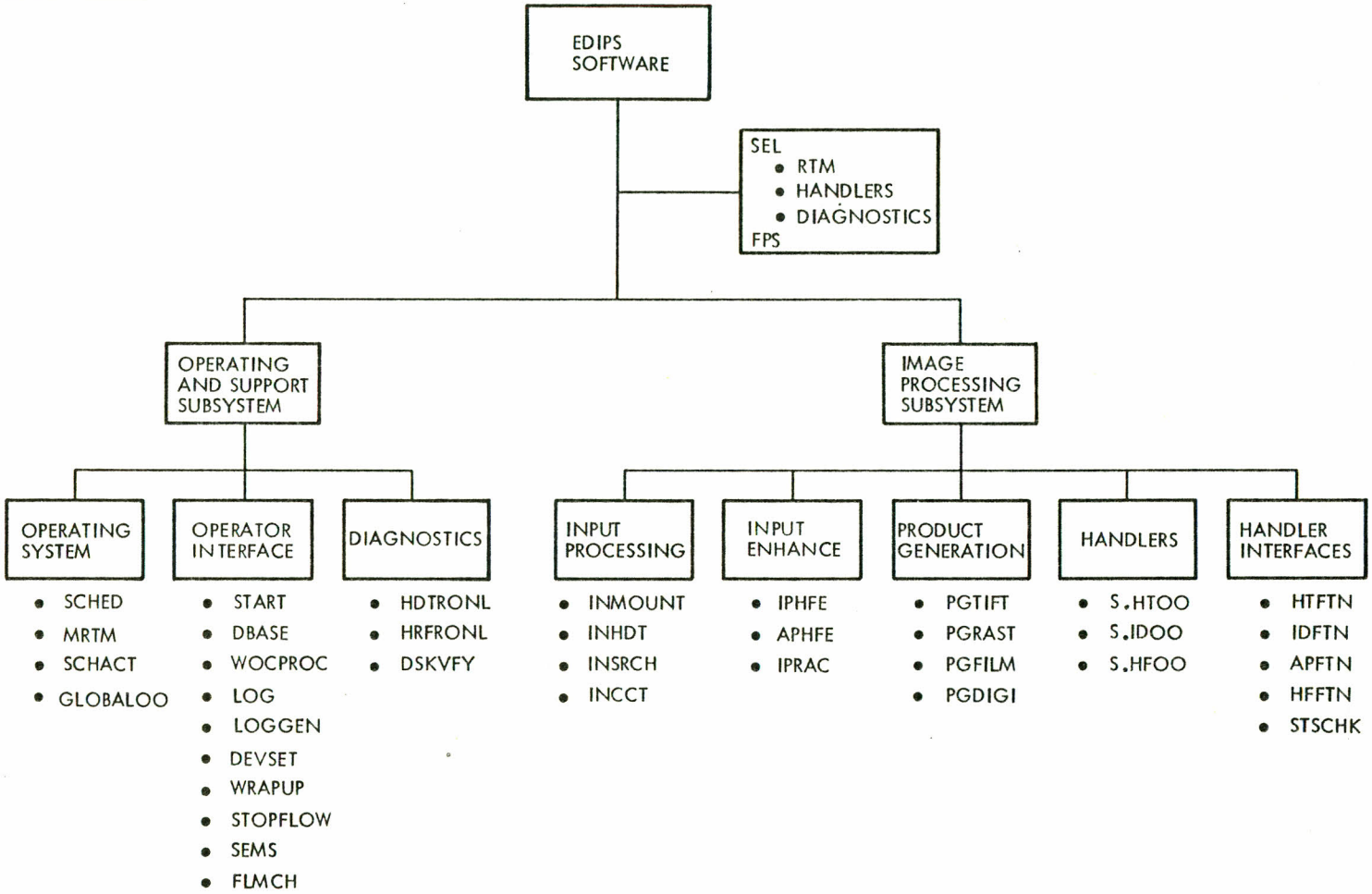


Figure 1-4. EDIPS Software Organization

EDIPS operates in either of two processing modes: Standard (commonly referred to as Pipeline), or Special Order. The difference between these two processing modes lies in the inputs, processing functions, and outputs. Table 1-2 summarizes the features of these two modes.

Table 1-2. Processing Mode Summary

Processing Mode	Input	Processing Functions	Output
Standard (Pipeline)	HDT_{PM}, HDT_{PR}	• Histogram • Contrast Stretch • Haze Removal • Film Formatting • Transient Image File Tape (TIFT)	• 241 MM Film
Special Order	HDT_{PM}, HDT_{PR}	• Histogram • Contrast Stretch • Haze Removal • Edge Enhancement • Film Formatting • CCT Reformatting • TIFT	• 241 MM Film • 800/1600 CCT: RBV Scene Sequential, MSS Band Sequential, Band Interleaved by Line
	HDT_{AM}, HDT_{AR}	• Histogram, • TIFT • CCT Reformatting	• 800/1600 BPI CCT
	800/1600 BPI CCT	• TIFT	• 241 MM Film
Special Case*	HDT, CCT	• Direct Dub (Offline)	• HDT, CCT Duplicates

*Note: Special Case processing consists of offline copying of HDTs or CCTs, and the transcription of CCT_A data to film without additional processing.

a. Standard (Pipeline) Processing

This mode of processing consists of initial transcription of data from HDT_p to film. All data input is radiometrically and geometrically corrected to the Universal Transverse Mercator coordinate system. All scenes on the HDT are transcribed, and the data on each are processed with identical steps including automatic contrast stretch and haze removal. A Transient Image File Tape (TIFT) is produced, and a processing log is kept.

b. Special Order Processing

This processing mode is used for transcribing data from HDTs to film or computer compatible tapes (CCTs). This mode provides the flexibility for tailoring the processing flow to a particular set of image data required (e.g., specific MSS scenes, specific bands within a scene, etc.). Any subset of the image enhancement algorithms (from all to none) can be selected.

c. Processing Thruputs

The EDIPS system is capable of processing approximately 200 MSS scenes and 160 RBV subscenes in a 13-hour period (the normal operating period each workday). Naturally, the actual number of scenes and subscenes processed depends on the mix of special order and pipeline tasks as well as the amount of enhancement processing to be performed. Table 1-3 lists a mix of tasks that may be typically processed in a 13-hour period.

1-6. PRODUCTS GENERATED

EDIPS products include film, HDTs, and CCTs. A Transient Image File Tape (TIFT) and processing log are also produced for use by EDC. The major attributes of each of these products is summarized below.

1-7. FILM PRODUCTS

Figure 1-5 is a typical film product (reduced approximately 25 percent from the original). Negative or positive, true or reverted, film images can be selected by the EDIPS operator. Utilizing data input in the HDT format, EDIPS produces the marginal annotations for each scene including longitude/latitude notations and tic marks, image ID characters, WRS path and row numbers, gray scale, and roll/frame number. The image ID characters include date, center coordinates, sensor type(s), band number, sun elevation/azimuth, and NASA ID code information. EDIPS extracts these data from the HDT data and rasterizes them for film imaging.

Additional information on thruputs is provided in Section IV.

Table 1-3. EDIPS Thruput

Mode/Task	Input Mix	Processing Performed	Output Product
Pipeline HDT_{PM} To Film HDT_{PR} To Film	200 MSS Scenes 160 RBV Subscenes	All receive: Contrast Stretch, Haze Removal, Film Formatting	Film
Special Order HDT_{PM} To Film HDT_{PR} To Film	27 MSS Scenes 21 RBV Subscenes	All receive: Contrast Stretch, Haze Removal, Film Formatting In addition, 1 MSS scene and 1 RBV subscene receive edge enhancement	Film
HDT_{PM} To CCT HDT_{PR} To CCT	9 MSS Scenes 4 RBV Subscenes	All receive: Contrast Stretch, Haze Removal In addition 1 MSS scene and 1 RBV subscene receive edge enhancement	CCT
HDT_{AM} To CCT HDT_{AR}	9 MSS Scenes 4 RBV Subscenes	Direct Copy	CCT

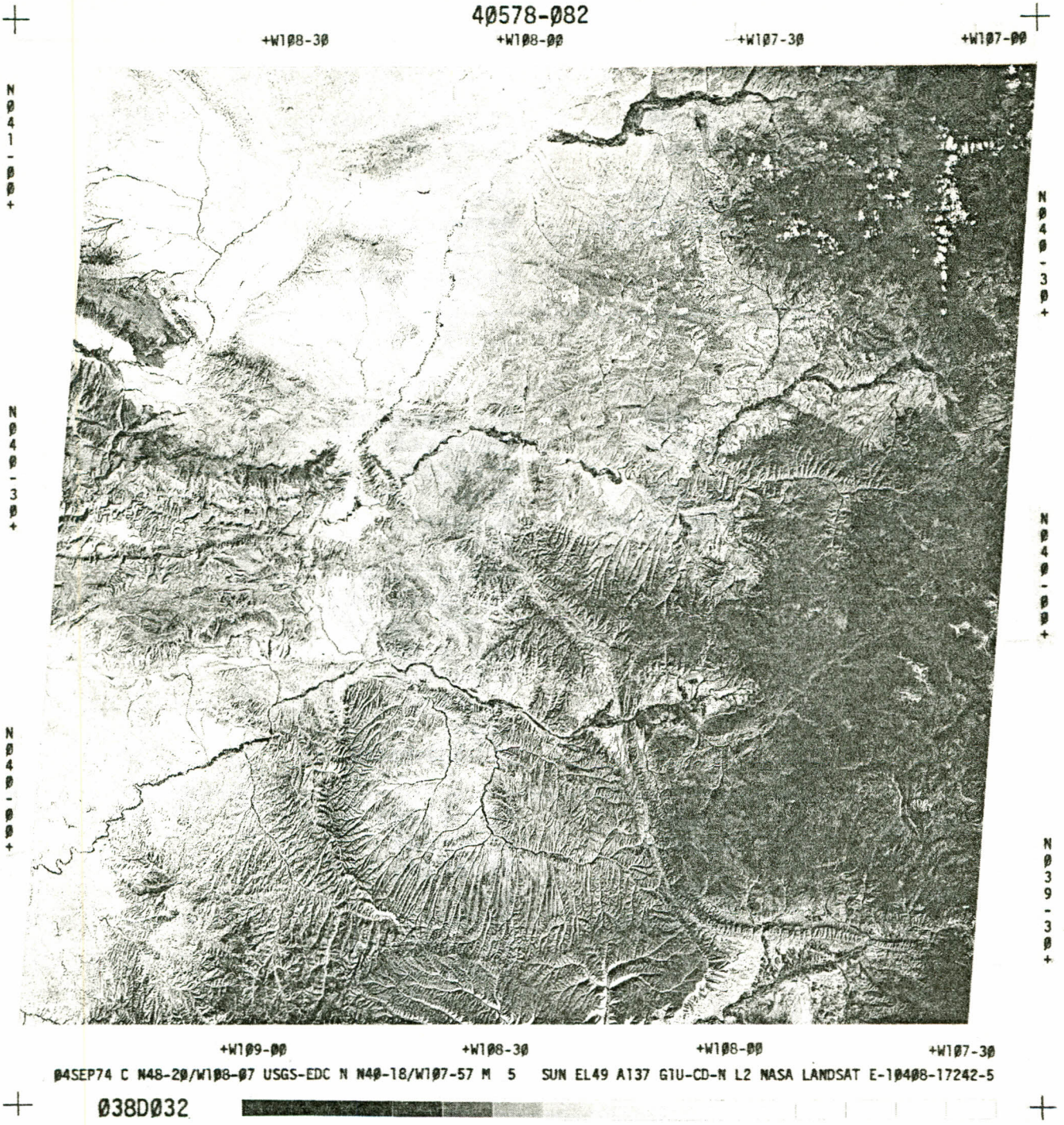


Figure 1-5. EDIPS Film Product

1-8 TAPE PRODUCTS

EDIPS produces Computer Compatible Tapes (CCTs) and direct copy HDTs. Output CCTs are recorded on 800/1600 BPI, 9-track, 1/2 inch tapes. The EDIPS operator can select different CCT formats from input HDTs. All inputs are MSS Band Sequential (BSQ) or RBV Subscene Sequential (SSQ), but outputs can be BSQ, Band Interleaved by Line (BIL) for MSS scenes, or SSQ for RBV subscenes.

EDIPS produces an individual printout for each CCT processed from any HDT. This printout is generated concurrent with the CCT it represents. Figure 1-6 illustrates the processing and quality data included on these CCT printouts.

1-9. RELATED DOCUMENTS

The EROS DIGITAL IMAGE PROCESSING SYSTEM OVERVIEW, EDIPS-370 provides a general description of the EDIPS system including the purpose, functions, hardware, software, and system interfaces. It is a good starting point for the uninitiated reader who requires only a general overview of EDIPS.

The EDIPS OPERATION AND MAINTENANCE HANDBOOK, EDIPS (No. TBS), provides a full and detailed description of how to operate and maintain the system, subsystems, and hardware/software elements. It contains step-by-step procedures for operating EDIPS, and information which enables technically trained personnel to maintain the EDIPS hardware and software.

The LANDSAT DATA USERS HANDBOOK, Document No. 76SD4258, published by NASA/GSFC in Greenbelt, Maryland describes the LANDSAT system and provides detailed descriptions of data products, sources and procedures for obtaining LANDSAT data and products.

Manufacturer's operation and maintenance manuals for the major hardware equipments are maintained in an updated form at EDC. These are listed in the EDIPS Operation and Maintenance Handbook referred to above.

USGS EROS DATA CENTER
CCT SUMMARY SHEET

DATA IDENTIFICATION	IMAGE 4	IMAGE 5	IMAGE 6	IMAGE 7	IMAGE 8
CCT INTERLEAVING FORMAT:	BIL				
CCT DENSITY:	1600 BPI				
HDT TYPE:	P				
ORDER NUMBER:	TTSOMSS 51				
UNIT NUMBER:	001				
HDT TAPE NUMBER:	L3MHP7700501				
DATE TAPE GENERATED:	24/ 1/78				
MICROFILM CASSETTE/FRAME:					
ROLL ID:					
FRAME NUMBER:	0	0	0	0	0
DATA QUALITY					
NUMBER OF IMAGE SCANLINES:	2983	2983	2983	2983	2983
BAND QUALITY CODES:					
INPUT STATUS CODES:	0	0	0	0	0
PROCESSING STATUS CODES:	0	0	0	0	0
NUMBER LINES SUBSTITUTED:	0	0	0	0	0
NUMBER LINES FILLED, INPUT:	0	0	0	0	0
NUMBER LINES FILLED, OUTPUT:	0	0	0	0	0
NUMBER LINES REPLACED:	0	0	0	0	0
NUMBER PARITY ERRORS:	33	0	0	142	376
NUMBER RETRIES:	1	0	0	0	0
DATA TRANSFORMATIONS					
PRODUCT CODE:	84				
PROCESSING CODES:	73, 92, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0				
EDGE ENHANCEMENT KERNEL:	0 LINES, 0 PIXELS				
HAZE REMOVAL BIAS:	0	0	0	0	0
CONTRAST STRETCH UNITS:	0				
MIN CONTRAST STRETCH CUTOFFS:	0	0	0	0	0
MAX CONTRAST STRETCH CUTOFFS:	0	0	0	0	0
SPACECRAFT DESCRIPTION					
SPACECRAFT:	03				
SENSOR:	MSS				
ORBIT NUMBER:	123				
IMAGE IDENTIFICATION					
IMAGE ID:	30002120004				
PATH:	A00				
ROW:	1102				
TRIG-A TIME:					
CENTER PICTURE EXPOSURE TIME:	77002120000000				
FORMAT CENTER LAT/LONG:	C N33-15/W1A00181				
CLOUD COVER:					

Figure 1-6. EDIPS CCT Printout

SECTION II

SYSTEM DESCRIPTION

This section provides a general description of both the hardware and software elements of the EROS Digital Image Processing System (EDIPS). Included are descriptions of the overall system, the major subsystems and associated hardware elements, and the software modules required to perform the various processing functions.

2-1. GENERAL

The EDIPS system is an integrated, highly automated, data processing system which extracts digital image data from high density tapes, enhances the imagery, and records the resulting processed data on high resolution film or computer-compatible tape (CCT). All processing functions are performed by a minicomputer system under program control of unique software modules especially developed for EDIPS processing tasks. Selection of the proper software modules is determined by specific processing requirements as defined on work order cards prepared to customer specifications. Operator input/output terminal devices are provided to permit necessary operator intervention including system startup, card loading, manual override operation, and other manual functions. A more complete description of equipment operation and the processing control functions performed by the software modules is provided in the following paragraphs.

2-2. HARDWARE DESCRIPTION

The EDIP system primarily consists of four basic subsystem elements; an input subsystem, a processing subsystem, an output subsystem, and a man/machine interface subsystem. Figure 2-1 illustrates the basic data flow between these subsystems and identifies the hardware elements comprising each subsystem. A description of each subsystem and associated hardware elements is provided in the following paragraphs.

2-3. INPUT SUBSYSTEM

The input subsystem consists of two high-density tape recorders, three serial controller interface units, and a histogrammer controller subsystem. Under computer control, the subsystem inputs MSS/RBV image data from HDTs, converts the data to a parallel format, and creates a histogram for each image. The data are then retained within system storage to provide image enhancements. The input subsystem is also capable of recording duplicate HDTs of input data. CCTs can also be inputted to EDIPS through use of a magnetic tape unit

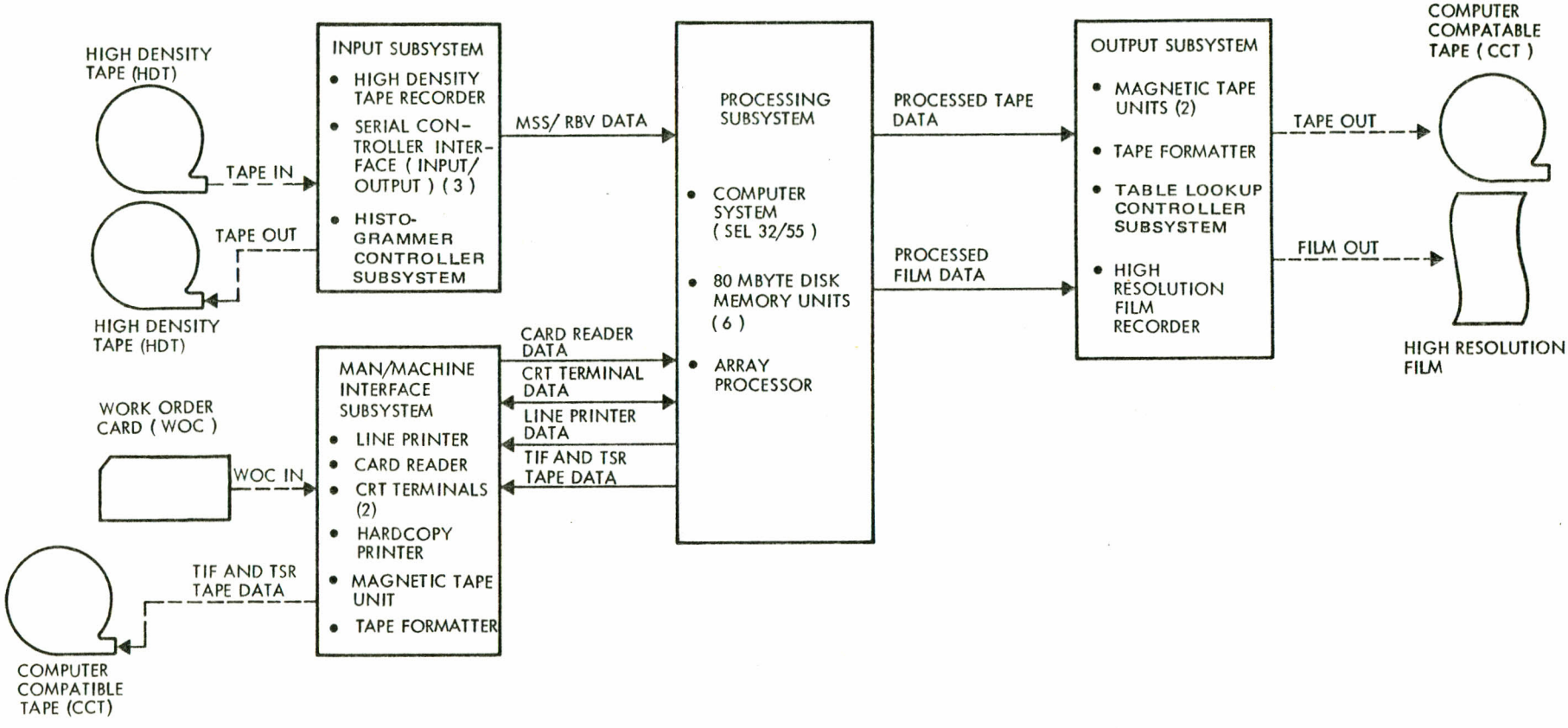


Figure 2-1. EDIPS Overall Block Diagram

to produce film products or direct transcriptions of additional CCTs. The following subparagraphs provide a description of each of these equipments and their interface relationships. Refer to the simplified block diagram in Figure 2-2.

2-4. HIGH DENSITY TAPE RECORDER (HDTR). The HDTR is capable of recording and reproducing a serial data stream over a wide range of data rates and tape speeds. Digital image data are recorded on 10 parallel tracks with 2 tracks reserved for auxiliary data. Track 1 carries a IRIG-A time code to provide a tape search capability at speeds up to 240 ips; track 2 can be used for general information. Sync words are also inserted to provide deskew capability to properly recombine the parallel channels into a serial bit stream during playback. Tape wind/rewind operations are performed at 300 ips. The HDTR has a read-after-write checking feature with front panel sync word and error displays for each channel. Two HDTR's are provided in the system to permit overlapped searches, HDT copying, and redundant hardware resources.

A more detailed description of the HDTR unit is provided in the following manufacturers' equipment manuals:

a. Maintenance Instructions for Model Ninety-Six Magnetic Tape Recorders/Reproducers System-Honeywell Test Instruments Division.

b. Operations and Maintenance Manual for High Density Digital Tape Recorder System - Martin Marietta Aerospace Denver Division.

2-5. SERIAL CONTROLLER INTERFACE (SCI). Each of the three SCI units utilized in EDIPS supervises the transfer of data between two high density tape recorders and the computer. Two SCI units perform tape-to-computer data transfer operations while the third SCI performs a computer-to-tape data transfer. The primary functions performed by the SCIs are described as follows:

a. Data formatting. (HDT Recording) Inserting sync words, frame type and number, scan line ID (this information must be supplied by the host once each major frame); providing filler when necessary (i.e., to fill out the last bits of an image frame which does not contain an integral number of data words); parallel-to-serial conversion.

b. Data stripping. (HDT Reading) Achieving and maintaining sync with recorded data; stripping off sync words, etc., justifying image words within fields before transferring to the host; serial-to-parallel conversion.

c. HDTR control. Providing all commands necessary to the HDTR to move tape, read and record, search for start or stop times, count parity errors, and monitor status.

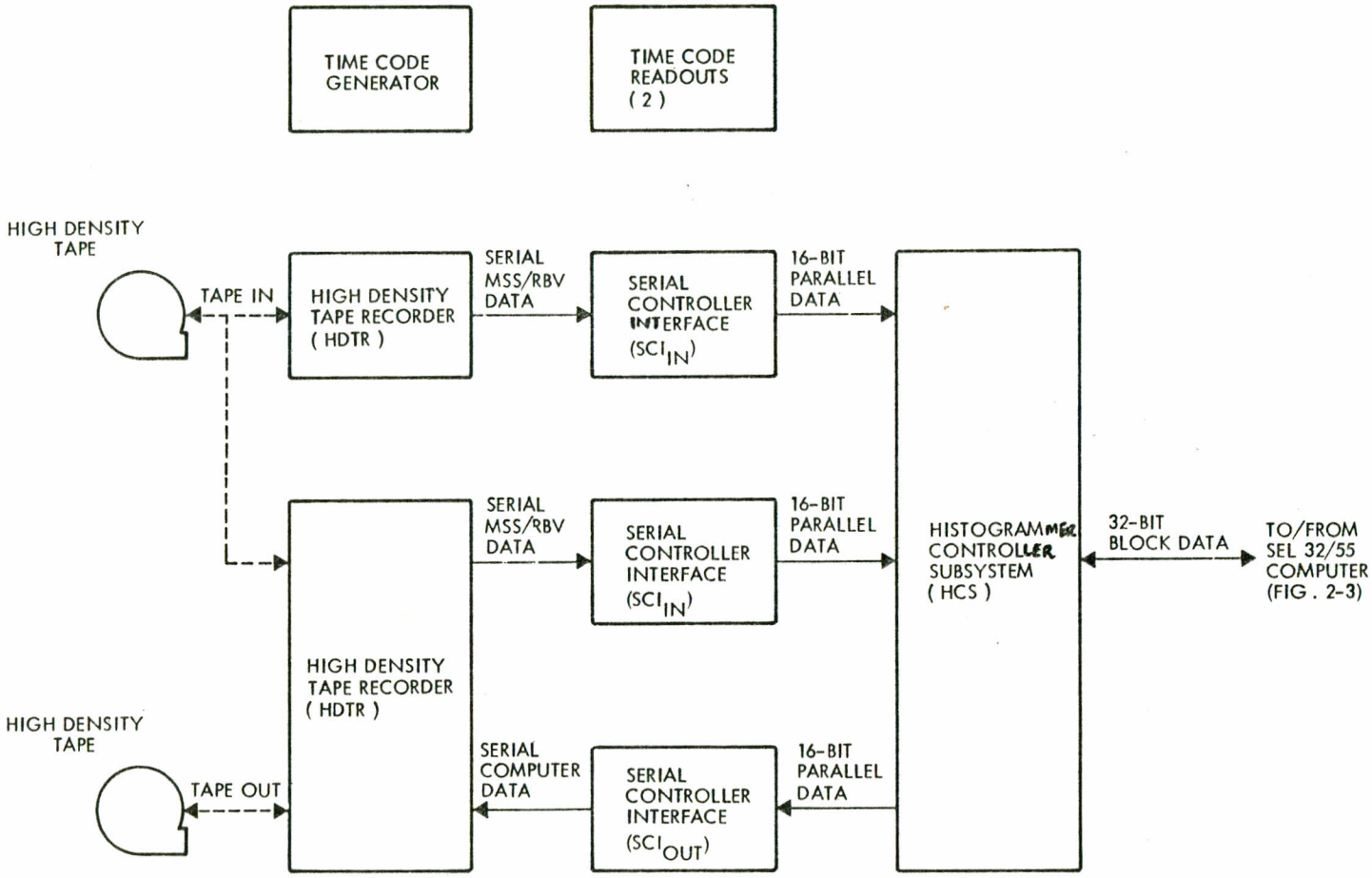


Figure 2-2. Input Subsystem Block Diagram

d. CPU interface. Interrupts the computer whenever its attention is required (i.e., to notify it of data received or sync loss, etc.).

e. Panel display. Controlling a variety of displays and indicators to inform the operator of certain operating parameters and events.

f. Error recovery. Ability to identify and recover from certain error conditions.

When the SCI is operated in the tape-to-computer data transfer mode, the input to the SCI is a serial data bit stream (NRZL), an in-phase data clock, and a IRIG-A time code. The source of these input signals is the high density tape recorder. The SCI performs a high-speed search of the digital tape to a time specified by the computer. The SCI then automatically slows the tape drive to the proper speed required for the subsystem, performs frame synchronization of the data, performs a serial-to-parallel conversion, and presents the data to the computer (via the histogrammer controller subsystem) through a memory port as soon as either: (a) a successful comparison is made between the scan line identification code in the data and a code selected by the computer; or (b) the data frame type specifying the major frame type selected is decoded by the SCI.

When operated in the computer-to-tape data transfer mode, the SCI accepts an initial time code from the computer. The SCI then generates an IRIG-A time code (starting from the initial time) upon command from the computer. The SCI also accepts data via a memory port, adds the frame synchronization code and frame type indicators where necessary, converts the parallel data to serial form, generates an in-phase data clock coherent with the serial data, and outputs the serial data, data clock, and IRIG-A time code to the HDTR.

A more detailed description of the SCI is provided in the EDIPS Serial Controller/Interface Maintenance and Operation Manual - General Electric.

2-6. HISTOGRAMMER CONTROLLER SUBSYSTEM (HCS). The HCS is a bidirectional block transfer device which serves as an interface between each of three SCI units (two input and one output), and the SEL 32/55 computer. The HCS interfaces with each SCI through 16-bit parallel data lines while computer interface is provided over 32-bit bidirectional data lines. The HCS also constructs a histogram of the picture elements (pixels) as they are transferred from the HDTR (via the input SCI) to the computer. The maximum pixel transfer rate is one pixel every one μsec (one megabyte/sec). Histogram generation is based on the distribution of radiance values of pixels against the digital count for each MSS band or RBV subscene processed. Once a histogram is generated for an image, the

data are transferred to the computer and the histogram array is cleared to ready it for the next image. A typical sequence of operation is decribed as follows:

a. Transfer register data to/from HCS and SCI registers. The registers are up to 48-bits long and are of several types (command, status, data format specification, time codes, etc.). The HCS also has the capability to block-transfer registers in the HCS and a particular SCI.

b. Transfer data from an input SCI to the computer, histogramming or not histogramming as specified by the histogram off/on register. Two commands are available for this process. One command synchronizes the HCS with the start of the Major Frame, while the other indicates data transfer to proceed from within the Major Frame. The histogram may be turned off for a whole major frame, in which case no histogramming will take place; or it will be turned on in the mid-portion of the scanline to histogram the image portion. Every single pixel will then be histogrammed. Before turning on the histogrammer, the HCS will check that the data in transfer are indeed image data. (Image data are identified by the [11101101] bit pattern in the 6th byte of the present scanline block transfer.) If the data are other than an image frame, the histogrammer is overriden, and the data are passed through unhistogrammed. This condition as well as other error or significant event conditions are indicated in the HCS status register and the computer alerted as specified by the HCS command register.

c. Transfer data to an output SCI without histogramming the data.

d. Transfer the histogram into the computer and clear the histogram array to ready it for subsequent histogramming of the next image.

e. Handle non-data transfer commands to the HDTR/SCIs. This can consist of searching on-time code, fast forward, rewind, etc. The HCS will handle simultaneous nondata transfer operations on one or more SCIs concurrent with, at most, one data transfer operation on another SCI. The HCS will be able to notify the computer of a significant non-data transfer event, such as time-code reached, major status change, etc., as controlled by the HCS command register.

A more detailed description of the HCS is provided in the Histogrammer/Controller Subsystem Technical Manual-Culler/Harrison, Inc.

2-7. PROCESSING SUBSYSTEM

The processing subsystem utilizes a 32-bit minicomputer as its primary component in controlling all processing functions with a minimum of operator intervention. The computer

contains a central processing unit (CPU), 16-8K word core memory modules, 2 memory bus controllers, 3 high-speed data interface units, 4 moving head disk controllers, various peripheral device controllers and a system array processor within the subsystem. A simplified block diagram of the processing subsystem is shown in Figure 2-3.

As shown in Figure 2-3, all high-speed data flow between the CPU, memory modules, data interface units, and device controllers is provided over a 32-bit parallel, bidirectional data bus. The data appearing on the bus are time-division multiplexed at a continuous rate of 26.67 megabytes/second and data transfers occur every 150 nanoseconds. The bus also contains 24 address lines that are used to address the input/output devices or memory locations for a read or write operation. Both data and address lines operate concurrently. The key element in the computer is the CPU which continuously and automatically operates on instructions from software modules stored in memory. These instructions control the system hardware which performs the various processing tasks. The following subparagraphs provide a brief description of each unit comprising the processing subsystem. For a more detailed description, refer to the SEL 32 Series Computer Technical Manuals.

2-8. HIGH SPEED DATA INTERFACE (HSD). The computer contains three HSD units, each of which provides a 32-bit parallel data interface between the SEL data bus and a respective I/O device (array processor, histogrammer controller subsystem, and table lookup/controller subsystem). These devices control the data transfer and can specify the address of any location in memory, and either enter or extract data from that location.

2-9. DISK MEMORY UNITS AND CONTROLLERS. The processor subsystem utilizes six disk memory units each of which provides 80 megabytes of random access storage and has an average access time of 30 msec. The disks are used for storing image data (MSS or RBV), annotation data, and program storage. Interface between the disk memory units and the SEL data bus is provided through four moving-head disk controllers (two controllers each interface with two disks, and the remaining two interface with individual disks). Operating on instructions from the CPU, each controller transfers data between its respective disk memory unit(s) and the computer.

2-10. CORE MEMORY MODULES AND CONTROLLERS. The computer contains 16-core memory modules, each of which has a storage capacity of 8192 words (32,768 bytes). Each memory is organized into 36-bit words (32 data bits plus 4 parity bits). The core memory modules are primarily used to buffer the data in transit between asynchronous devices such as tapes and disks. Two memory bus controllers (MBCs) provide interface between the SEL data bus and the core memory modules, with each controller interfacing with eight modules. The MBC controls the

memory read/write functions and operates synchronously with the CPU to provide full 32-bit word transfers every 150 nanoseconds. In the write mode, the MBC receives a 32-bit data word and the address of the storage location in memory. The data transfer to core memory is then performed by the MBC and the CPU is free to perform another transfer operation. Memory read operations, however, require two transfer operations on the SEL data bus. On the first transfer, the MBC takes the address of the memory location to be read, and the address of the requesting device. While the MBC is accessing the data from memory, the SEL data bus is available to other devices. When the data is read from memory, the MBC requests priority on the data bus. When it gains access to the bus, the data is then transferred to the address of the requesting device.

2-11. ARRAY PROCESSOR. The array processor is a floating point arithmetic processor that manipulates data at a high speed in order to perform high frequency edge enhancement on RBV or MSS images. The edge enhancement algorithm utilizes spatial (box) filters to boost the proportional contributions of high frequency spatial variations and the array processor handles the transform computations. The pixels are transformed from integer to floating point formats; they are operated on, reconverted, and returned to the CPU buffer. Data transfers to and from computer memory are accomplished through the HSD controller.

2-12. TLC TERMINAL CONTROLLER. The TLC terminal controller provides the interface channels and input/output control for the operator CRT terminal, a line printer, and a card reader. The controller permits simultaneous operation of all three terminal devices. By execution of a single command device instruction by the CPU, any one of three channels in the controller can be conditioned for a block transfer to or from the respective terminal device. After completing the block transfer, the controller signals the CPU by means of an interrupt. The CPU then executes a test device instruction to determine whether the transfer was successful and, if not, what errors were encountered.

2-13. MAGNETIC TAPE CONTROLLER. The magnetic tape controller interfaces the SEL data bus to the tape formatter and controls the transfer of block data to the magnetic tape unit (MTU). The processor subsystem utilizes two tape controllers, one of which controls the MTU that produces the TIFT. The tape controller operates on a single command device instruction to transfer a block of 32-bit data from memory to a selected MTU. When a block transfer operation is completed, the controller provides an interrupt signal to the CPU. The CPU then executes a test device instruction to determine whether the transfer was successful and if not, what errors were encountered.

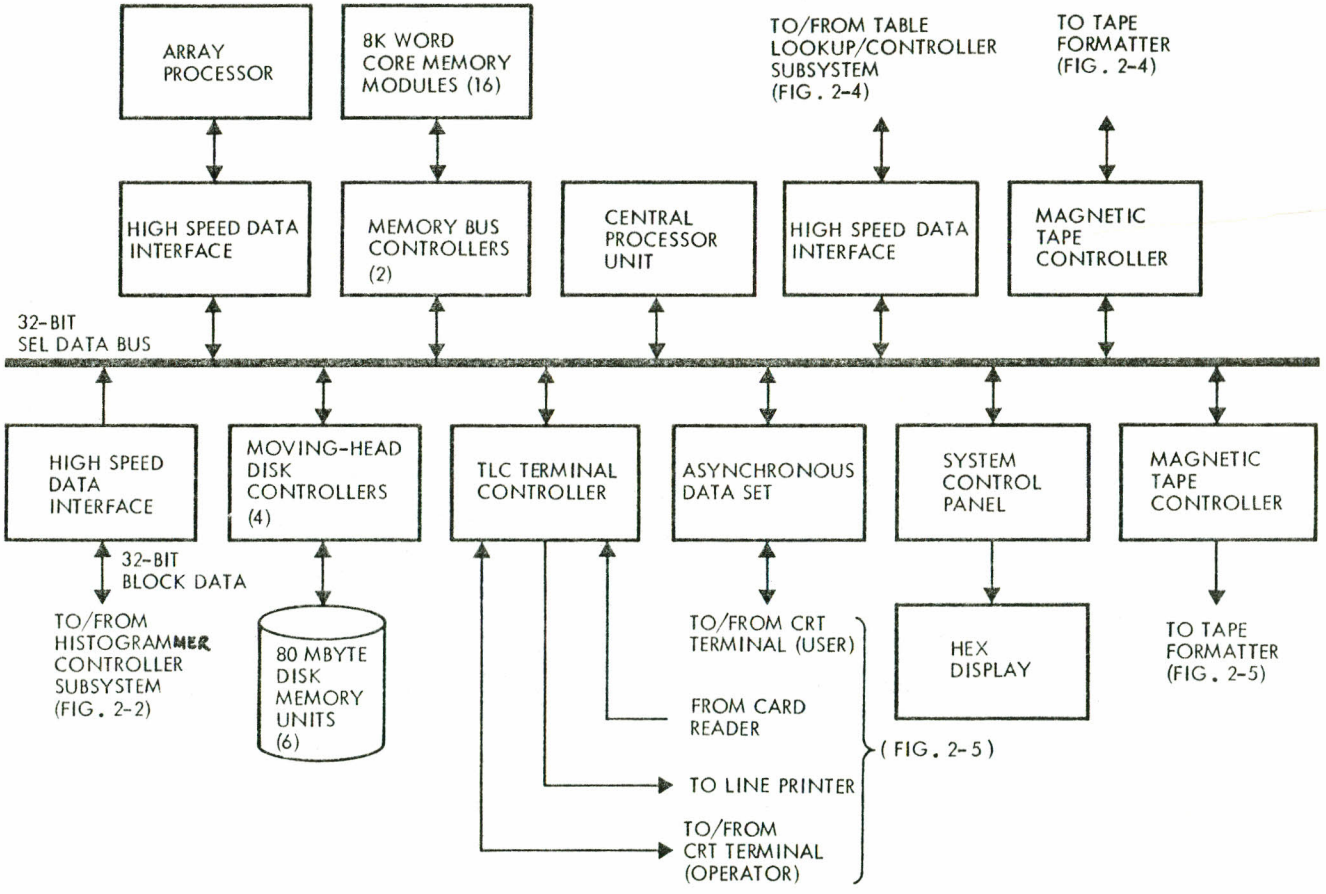


Figure 2-3. Processing Subsystem Block Diagram

2-14. OUTPUT SUBSYSTEM

The output subsystem performs the final processing operations in producing high resolution film and computer compatible tape products. The subsystem consists of a tape formatter, a table lookup/controller subsystem, two magnetic tape units, and a high resolution film recorder. The following subparagraphs provide a brief description of each of these equipments and their interface relationships. Refer to the simplified block diagram in Figure 2-4.

2-15. TABLE LOOKUP/CONTROLLER SUBSYSTEM (TCS). The TCS is a bidirectional block transfer device with a 32-bit word size, and transfer rates up to 250 thousand words/sec. The unit interfaces the computer data bus to the high resolution film recorder (HRFR) and translates picture elements for image enhancement as the data are transferred through to the HRFR. The functions performed by the TCS are summarized as follows:

a. Transfer command register data to the HRFR.

b. Transfers status register data from the HRFR and TCS.

c. Transfers data between the computer and the TCS lookup table (bidirectional). The lookup table consists of 256 8-bit byte entries.

d. Transfers image data from the computer to the HRFR, with or without table lookup and left shifting of the pixel within the byte, under the control of TCS registers preset by computer software. During table lookup enabled operation, the input byte is decoded to address 1 to 256 bytes in the lookup table, whose contents replace the input byte. The TCS will allow M bytes in the scanline to bypass the lookup table, the next N pixels will go through the lookup table, and the remaining pixels in the scanline will again bypass the table. N and M will be prespecified in a register transfer to the TCS. M and N will have a maximum of 16-bits significance each. The TCS will also be able to shift the image data bypassing or going through the look-up table 0,1, or 2 places to the left, under the control of a parameter preset by the computer. The pixel data before shifting, whether bypassing or going through the table, will be right justified in the byte with the unused leading bits set to zero. The TCS will shift in zeroes from the right. Image data through the TCS are packed 4 pixels to the 32-bit word transfer. The relative positions of the pixels within the word does not change between the input and output of the TCS. When a partial scanline is passed to the TCS, all pixels will be significant and will be transferred to the HRFR.

2-16. HIGH RESOLUTION FILM RECORDER (HRFR). The HRFR produces first generation film masters of image data inputted to the system on either high density tapes or CCT tapes. All

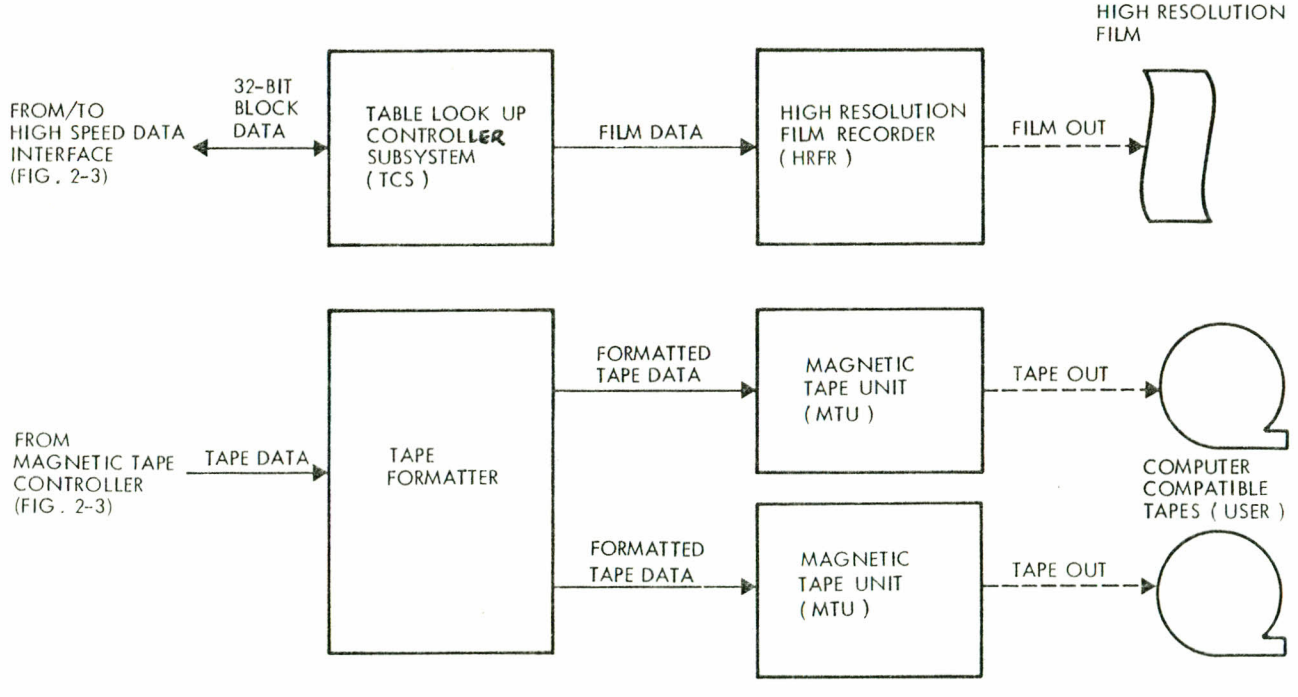


Figure 2-4. Output Subsystem Block Diagram

control and data signal interface to the HRFR is provided through the table lookup/controller subsystem.

The HRFR employs a laser light source and rotating mirror to expose film in a line-scanned format. The film size is 241 mm (9.5 inches). Several film types can be used; however, the primary film type is Kodak 2460 unsprocketed black and white roll film. During recording operations, the film is continuously driven in a direction orthogonal to the laser scan. The input digital data are assembled, line by line, in buffers and then clocked, pixel by pixel, into a digital-to-analog converter to modulate the laser light source during the active mirror scan period. The pixel clock is derived from a high resolution encoder linked to the scanning mirror drive motor. The modulated laser beam is passed through appropriate spot-forming and precision optics to the film. True or reverted, positive or negative film images can be produced by operator selection.

A typical HRFR operation cycle is as follows: The HRFR is placed in a standby or on-line condition by operator controls. Upon receipt of the record command from the computer, the HRFR switches to the record mode and film recording commences. The first scan line of data is assembled in one of the HRFR input buffers. Prior to buffer assembly, the digital image data values are adjusted by a selectable, radiometric lookup table to linearize the data commensurate with the D log E characteristics of the specific film type/lot in use. As the image data are being clocked out of the buffer at the HRFR pixel clock rate, the next scan line of data is inputted to a second HRFR buffer and similarly assembled. The buffers toggle back and forth and HRFR operation continues in this manner until a ready or standby command is received from the computer.

2-17. MAGNETIC TAPE UNITS (MTUs) AND TAPE FORMATTER. The magnetic tape unit is a synchronous digital magnetic tape recorder that is used in conjunction with a tape formatter to record digital image data on 9-track computer compatible tapes. The output subsystem utilizes two MTUs for generating user tapes, each of which receives NRZL or PE formatted data and control signals from a common tape formatter. The MTU records data at a tape speed of 125 ips and at tape densities of 800 or 1600 bits/inch, as specified by work order card inputs. The data transfer rate of the MTU is 100 kHz at 800 bits/inch or 200 kHz at 1600 bits/inch. The tape unit also has a read-after-write checking feature.

A basic write operation is performed as follows: Write data are applied to the tape formatter from the tape control unit over nine parallel data lines (eight data bits and one parity bit). The data are formatted to the NRZL or PE format, and the eight data bits appearing on the output lines are written onto corresponding channels on tape by the MTU.

A more detailed description of the MTU is provided in the Digital Magnetic Tape Recorder Operation and Maintenance Manual - Kennedy Co.

2-18. MAN/MACHINE INTERFACE SUBSYSTEM

The man/machine interface subsystem provides all control functions necessary for operator intervention with the system. These functions permit the operator to set up and configure the system, develop and modify software modules, execute software module processing operations, override programmed functions, and perform diagnostic testing and monitoring. The subsystem consists of a card reader, a line printer, a hard copy printer, two CRT display terminals, and a magnetic tape recorder and tape formatter. The following subparagraphs provide a brief description of each of these equipments and their interface relationships. Refer to the simplified block diagram in Figure 2-5.

2-19. CARD READER. The card reader performs the primary processing control function by reading control data from punched work order cards (WOCs) and entering the data into the processing subsystem. Based on these inputs, the processor automatically activates the appropriate modules in the proper sequence, and performs the associated processing functions. The data items on the work order cards specify the input media (HDT or CCT), algorithms to be applied, algorithm order (where applicable), processing parameters, output media (CCT or film), and output format and recording density (800 or 1600 bpi) for CCT products.

The card reader reads standard 12-row, 80-column punched cards in serial, column-by-column fashion. The unit is capable of reading 1000 cards/minute and has a hopper/stacker capacity of 1000 cards. Interface between the card reader and SEL data bus is provided through the TLC terminal controller.

A more detailed description of the card reader is provided in the M-1000L Card Reader Technical Manual-Documentation, Inc.

2-20. CRT DISPLAY TERMINALS. The interactive CRT display terminals are provided in the man/machine interface subsystem; one primarily for inputting and monitoring the processing (user terminal), and the other for program control by the system operator (operator terminal). The user terminal is interfaced to the SEL data bus through the asynchronous data set interface thereby providing full duplex operation. The operator terminal interfaces to the SEL bus through the TLC terminal controller which provides separate I/O control channels for the CRT display terminal, the card reader, and the line printers.

Each CRT display terminal consists of two units; a 96-character ASCII keyboard and a 128-ASCII character set display. The keyboard of the operator terminal provides the operator with complete on-line program control whereby any processing function may be initiated. The keyboard of the user terminal permits software programs to be developed, debugged, and modified. The display section of each terminal presents 24 lines of alphanumeric characters, with each line consisting of 80 characters (1920 characters total). The displays permit all data entered from the keyboard to be monitored, as well as data received from the processor.

A more detailed description of the CRT display terminals are provided in the ADM-2 and ADM-3 Maintenance and Reference Manuals - Lear-Siegler, Inc.

2-21. MAGNETIC TAPE UNIT (MTU) AND TAPE FORMATTER. The magnetic tape unit and tape formatter used in this subsystem are identical to the units previously described for the output subsystem (see Paragraph 2-17). These units, however, are strictly used to record transient image file (TIF) data consisting of geographic coverage, cloud cover, date of exposure, image data and sensor type, etc. These recordings are made for both the pipeline and special order products.

The tape formatter interfaces with the SEL data bus through a magnetic tape controller that is specifically designated for the TIFT function. The data are formatted and recorded on 9-track CCT for each MSS band or RBV subscene concurrent with the processing of the specific scene.

2-22. LINE PRINTER. The line printer provides a printout of the processing status of each user CCT produced by the system. The printout is generated simultaneously with production of the tape, and contains such information as quality data, scene parameters, processing operations performed, and similar data. It is also used to provide the processing log.

The line printer prints a full 64-character set in a 136-column format at a maximum print rate of 600 lines/min. The unit is interfaced to the SEL data bus through the TLC terminal controller.

A more detailed description of the line printer is provided in the Line Printer Technical Manual - Data Products Corp.

2-23. HARD COPY PRINTER. The hard copy printer interfaces with the operator CRT display terminal to generate hard copy recordings of information displayed on the CRT.

The hardcopy printer is an impact-type printer which prints a full 64-character set in a 80-column format at a

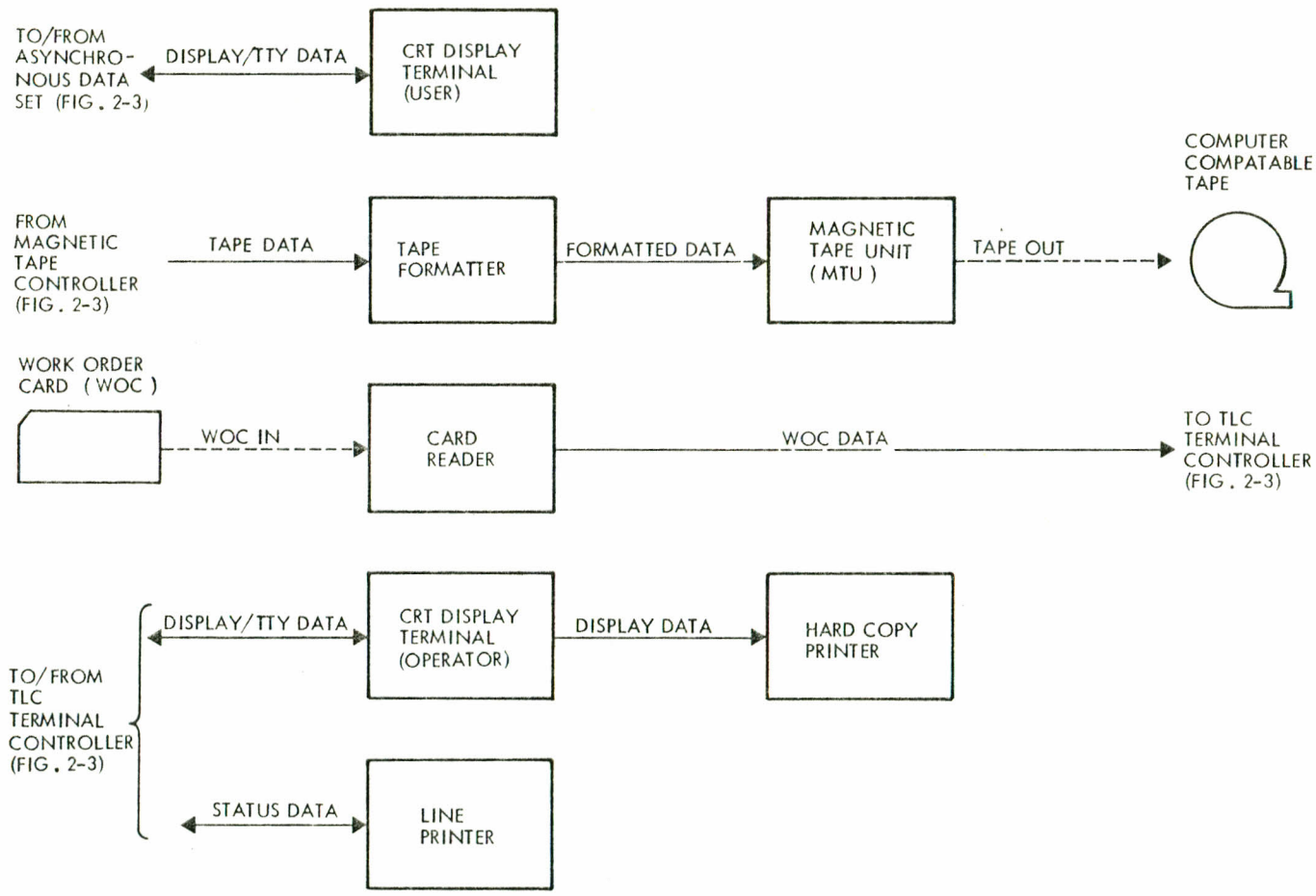


Figure 2-5. Man/Machine Interface Subsystem Block Diagram

maximum print rate of 30 characters/sec. The unit interfaces with the CRT display terminal through a standard RS-232C interface.

A more detailed description of the hard copy printer is provided in the Terminet 30 Printer Instruction and Service Information Manual - Data Communications Products, General Electric.

2-24. SOFTWARE DESCRIPTION

The EDIPS software consists of 36 modules designed and generated by TRW specifically for EDIPS application, plus 16 modules that were supplied by manufacturers of the system hardware. The software modules supplied by the hardware manufacturers and the associated reference documentation is listed in Table 2-1. Of the modules listed, only the SEL 32/55 Real Time Monitor is discussed in this handbook; a more complete description of RTM and the other software modules supplied by the manufacturers is contained in the referenced documentation.

Table 2-1. Manufacturer-Supplied Software

MANUFACTURER/MODULE NAME	REFERENCE DOCUMENT NO.
SEL-SUPPLIED SOFTWARE	
SEL Real-Time Monitor (RTM) Operating System	323321001-001
Extended FORTRAN IV	323-321012-001
Math Subroutine Library	323-321041-001
FORTRAN Support Library	323-321012-001
Scientific Subroutine Library	323-321043-001
Sort	324-321189-002
Level I Diagnostic Programs	SEL Model 1031
Level II Diagnostic Programs	SEL Model 1032
Level III Diagnostic Programs	SEL Model 1033
FPS-SUPPLIED SOFTWARE	
APAL Cross Assembler	
APEX Executive Program	
APLINK Linking Leader	
APSIM Simulator	
APDEBUG Debugging Program	
APTEST Diagnostic and Test Program	
Algorithm Library	

2-25. EDIPS EXECUTIVE

The executive system for EDIPS is the SEL-supplied 32/55 Real-Time Monitor (RTM). This is a disc-oriented, multiprogramming system that provides 64 software priority levels for controlling concurrent execution of multiple tasks in either the foreground or background. Multiple programs can be assigned to run under each software priority level, thereby providing virtually unlimited multiprogramming capabilities.

The RTM provides full capabilities for background processing of routine batch jobs. Background processing runs on a time-available basis concurrent with real-time foreground processing. The background has the lowest software priority (level 64), thus it is serviced after all tasks critical to real-time activities have been processed.

The Real-Time Monitor activates programs by interrupt, by monitor service requests, by commands from the operator, by job control directives, and by commands from the Timer Scheduler. Through these varied methods of program activation, the Real-Time Monitor provides flexibility to adapt the system operating modes to changing real-time conditions.

Standard features of the Real-Time Monitor include:

- Multiprogramming environment supporting concurrent execution of multiple programs
- Interrupt and trap processing for all levels
- Timer scheduling of foreground programs
- System security via dynamic memory protection feature
- Servicing of all standard peripheral devices
- Reentrant monitor services available to both foreground and background programs
- Dynamic allocation of memory
- File management
- Automatic roll-out of user programs
- On-line system control from the console
- Debugging with dump, snapshot, and trace
- Batch job processing through a job control language
- Program overlays

- Optional configuration of a reentrant version of the subroutine library
- System generation with hardware and software configuration options.

2-26. PROCESSING SOFTWARE ORGANIZATION

The EDIPS processing software is grouped into those modules which support the Operating and Support Subsystem, and those which support the Image Processing Subsystem. Figure 2-6 illustrates the organization of these groups of modules. A brief description of each module is provided in Appendix A.

2-27. SYSTEM FUNCTIONAL OVERVIEW

The design of EDIPS has produced a fully automatic processing system with several interesting features. The system generates output film products at a processing rate of over 700 kilobytes/second using commercially available components that interface, via special purpose hardware, to high-density tape recorders and laser-beam film recorders. The system utilizes a conventional minicomputer in an unconventional manner to perform the EDIPS tasks.

A simplified functional overview of EDIPS is shown in Figure 2-7. Data are inputted from either tape media. A histogram is generated by means of hardware for all new HDT data entered into the system; CCT input data has previously been histogrammed. All data, whether it be MSS or RBV, are stored on 80-megabyte disks in formats that do not change during processing; that is, the data are inputted onto one of three designated 80-megabyte disks, and remains on that disk throughout processing. The data are then transferred from the selected disk to the output media, whether it be film or tape. Therefore, the three designated disks are utilized in the system for data storage in the following operational sequence; input, processing, output, and then again back to input.

The MSS data are stored using a unique format concept called band-interleaved-by cylinder. This format allows maximum data transfer for all input and output products, whether they be annotated film products or specially formatted CCT products. Within the image disk, the multiple MSS bands are interleaved disk cylinder-by-disk cylinder (i.e., 20 lines of band 4 on one disk cylinder, the corresponding 20 lines of band 5 on the next disk cylinder, and so on). The band-interleaved-by cylinder format places the top rasterized film annotation data in a file above the image file, and the bottom rasterized annotation data in a file below the image file. This permits the scene-unique annotation data to be accessed easily for each band. In addition, ancillary data are also stored on the disk for easy access.

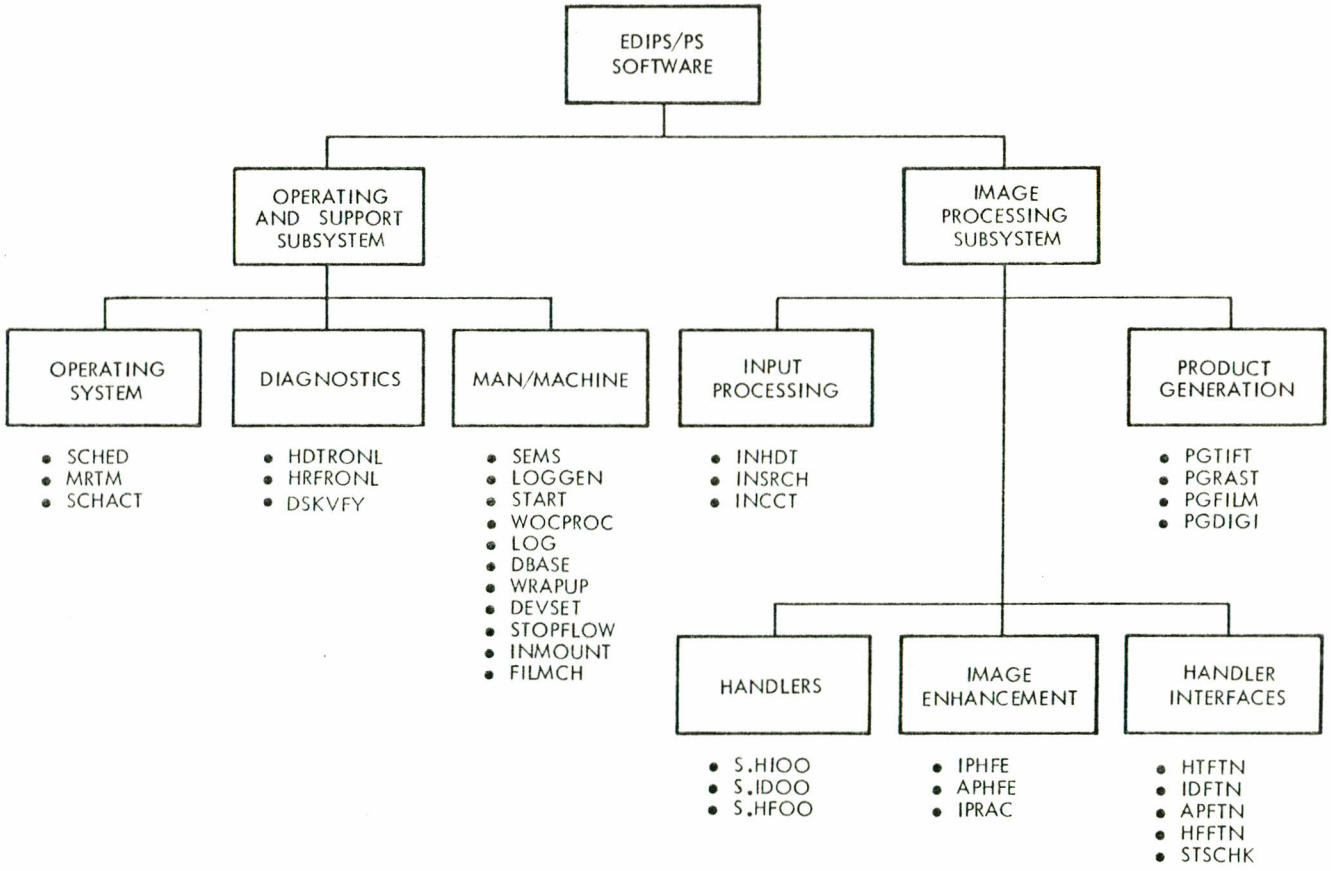


Figure 2-6. EDIPS Processing Software Organization

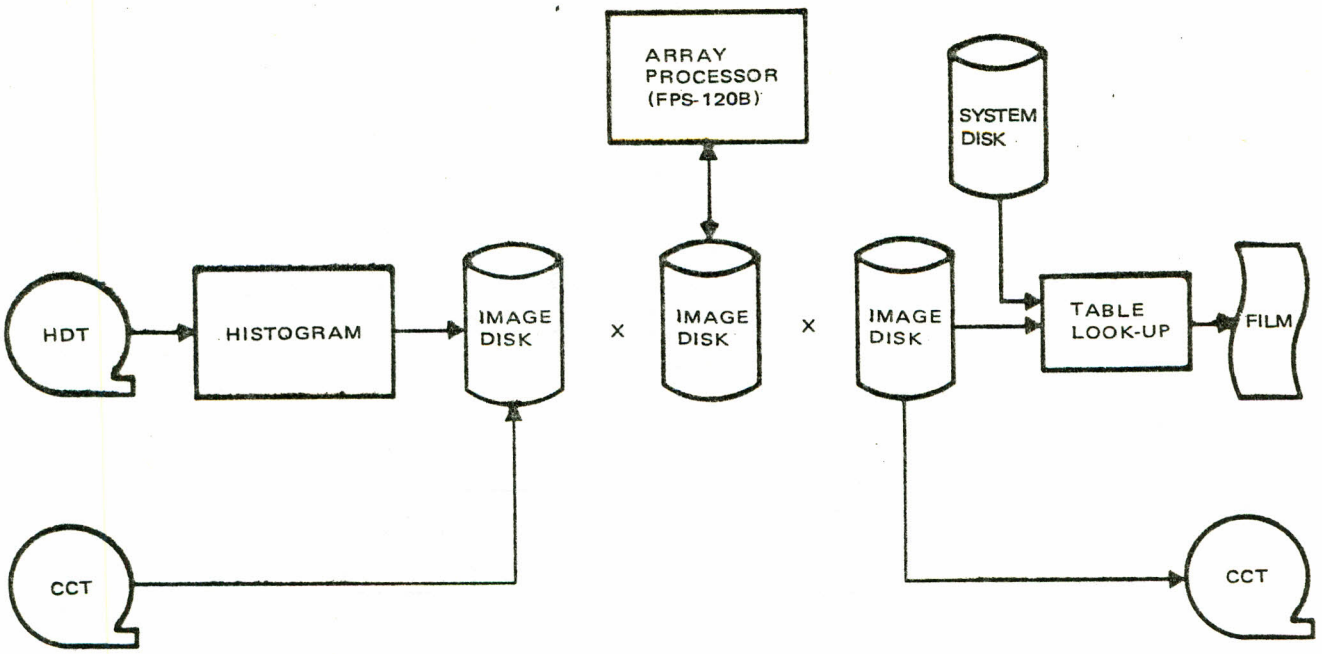


Figure 2-7. EDIPS Simplified Block Diagram

Specially designed buffer schemes for both input and output processes provide tolerance to I/O timing errors, and insure sustained thruput. Rasterized annotation data are merged with the image data and transferred through a hardware table look-up interface to generate the film products. The table look-up implements the contrast stretch and haze removal algorithms through the application of a radiance table adjustment. An additional image enhancement algorithm, high-frequency edge enhancement, is performed in an FPS AP-120B array processor to insure maximum thruput. In addition to the film products, CCT products are also produced in 800- and 1600- BPI densities, and in various formats, at the 125-ips tape-unit rate.

Only one software operating system is used to produce output data for all types of input data. The multi-tasking feature of the SEL 32/55 RTM operating system is used to provide completely overlapped processing for inputting data, enhancing images and rasterizing annotation, and generating output products. Data and command chaining attributes of the HSD SEL bus interfaces yield I/O processing without CPU resources. An EDIPS-designed event driven scheduler is used to increase thruput by organizing input tape searches and organizing the processing flow for maximum product generation.

For the pipeline process, care has been given to the selection of the input HDTR data rates and the output HRFR scanline film rates. A design goal to keep the input HDTR running continuously at the expense of stopping the HRFR transfers has been achieved by careful selection of the HDTR tape speed and HRFR scanline rates, as well as disk storage of each MSS scene and RBV subscene. The timing latency provided by the disk storage, in general, allows a full HDT reel to be inputted in the pipeline made before the tape must be stopped due to input/output rate differences. In the event of conflicts, the system design provides for stopping the HRFR rather than the HDTR. The software provides for a minimum of operation intervention; in fact, except for monitoring the processing, the operator task is primarily to supply input and output materials such as film and tape. The operation is fully automatic with complete error processing and operator prompting. A time-tagged processing log is generated for all system operations.

Much care has been given to the maintenance concerns of the system. Hardware redundancy has been emphasized to insure minimum downtime. This redundancy not only yields continued processing at a maximum thruput, but insures the availability of system processing in an environment of graceful degradation due to hardware failure. The system contains six identical 80-megabyte disk drives and four controllers; three of the six disks are used for image processing, one is used for the system, and two are spares. Even though three disk drives are needed for full image processing, output products can be generated automatically with only one image drive unit available. The system disk can easily be changed. Three 125-ips magnetic tape units are available, either singly or in multiple. Two input high-density tape units can also be used in a solo fashion. Either the card reader or the CRT terminals may be used as input media, and the magnetic tape unit, line printer, or CRT terminals may be used to output control variables. The hardware redundancy feature is implemented automatically in failure situations by the software to insure continued maximum thruput. By option, the operator can place hardware off-line without affecting the processing flow, and with minimal impact on the thruput. In addition, special software has been implemented to monitor the status of all peripheral devices, and to aid the operator in anticipating hardware failures.

Repair at the board, or card level has been proposed for situations which exceed the capabilities of the hardware redundancy. Thus, a goal of maximizing system operational availability and minimizing the time to repair hardware failures has been greatly realized.

SECTION III

THEORY OF OPERATION

This section contains a detailed system-level description of the operating and control functions performed by EDIPS in producing digital tape and film products. Included are descriptions of system operation, data processing modes, and automatic and manual control functions. Separate descriptions are also provided for the histogram generation and table lookup/control functions.

3-1. GENERAL DATA FLOW DESCRIPTION

The EDIPS system utilizes a SEL 32/55 minicomputer system as its primary component in controlling all data processing functions with minimal operator intervention. Under control of unique software modules, the system hardware extracts image units (MSS bands or RBV subscenes) from input magnetic tapes, enhances them, and digitally records them on computer compatible tapes or converts them to high-resolution film transparencies. A special software program is also provided to enable the system to record TIF and TSR data on computer compatible tapes while also providing a hardcopy printout. The specific processing requirements, as defined on work order cards, determine selection of the proper software modules required to perform the associated tasks.

A processing flow diagram showing basic data flow and the interrelationships between the hardware and software modules for a complete processing operation is shown in Figure 3-1 and described in the following paragraphs. For our discussion, the software modules are considered to be activated in sequence from left to right as shown on the diagram. In actual operation, however, two or more modules may be activated and operating simultaneously.

3-2. SYSTEM STARTUP

All EDIPS processing functions always begin with activation of the START module. This module is activated by means of the operator's CRT terminal when an ACTIVATE START command is entered. The module responds by checking the availability (presence) of each peripheral device through the real-time monitor (RTM) module. If a device is not present, a message is returned to the terminal and displayed on the CRT to indicate the condition. The operator must then decide whether the device is critical for performing the required processing operations. The minimum configuration required is as follows:

a. Operator's CRT terminal

b. At least two 80MB disks and controllers

c. At least one magnetic tape unit

d. Card reader and line printer or CRT.

If at least the minimum configuration is not available, the START program will exit and EDIPS cannot be operated until the required devices are made available.

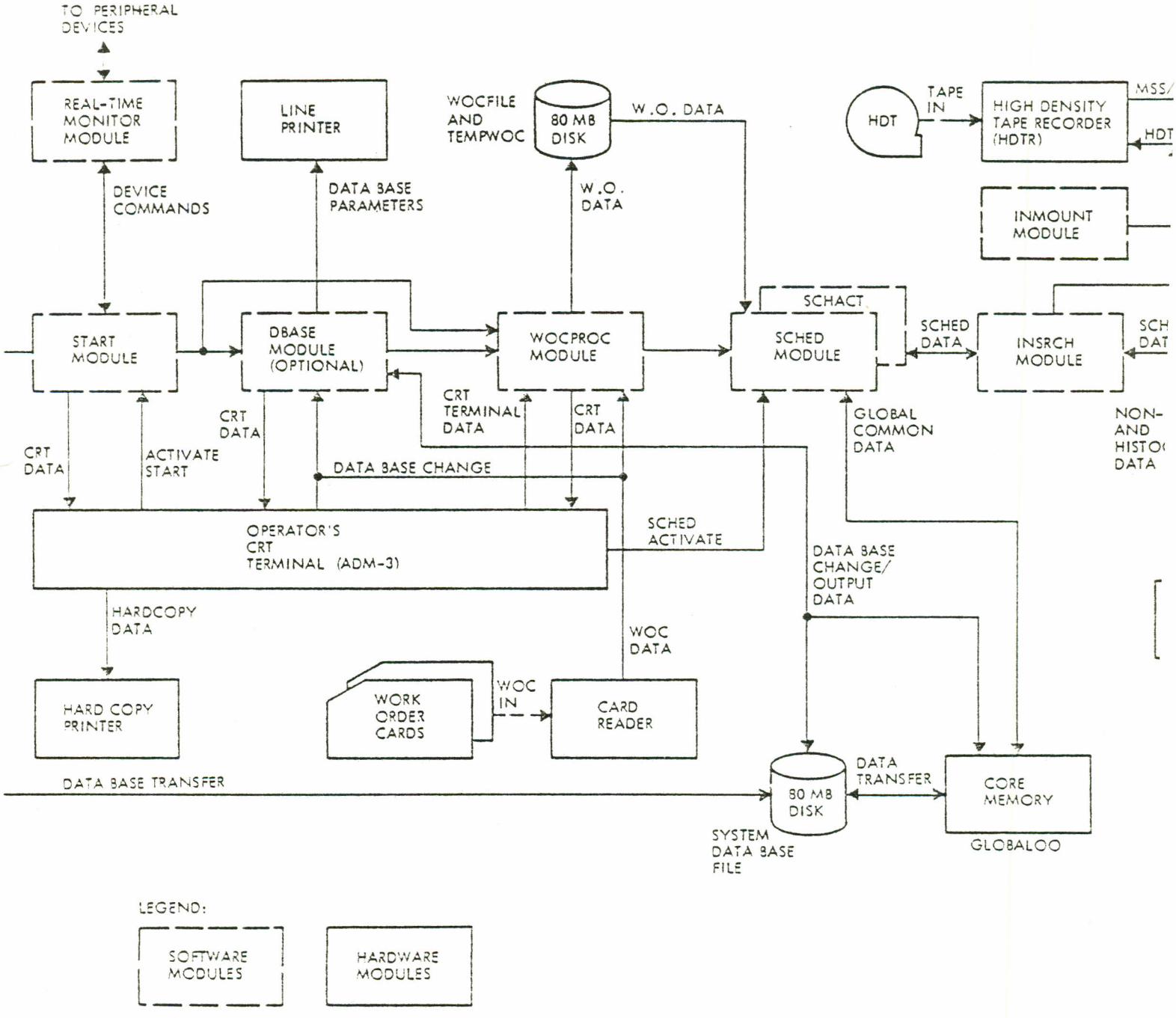
If the minimum configuration is available, the START module loads the static and dynamic data base stored on disk files into core memory, outputs the roll and frame number of the film in the HRFR to the CRT, and sets up any other initial conditions. If the roll of film in the HRFR is positioned at the correct frame for continued use by EDIPS, the operator responds via the terminal; if not, the operator enters the proper roll and frame number. When all operations are complete, START indicates that successful startup has occurred by displaying a PROCESSING MAY BEGIN message on the CRT.

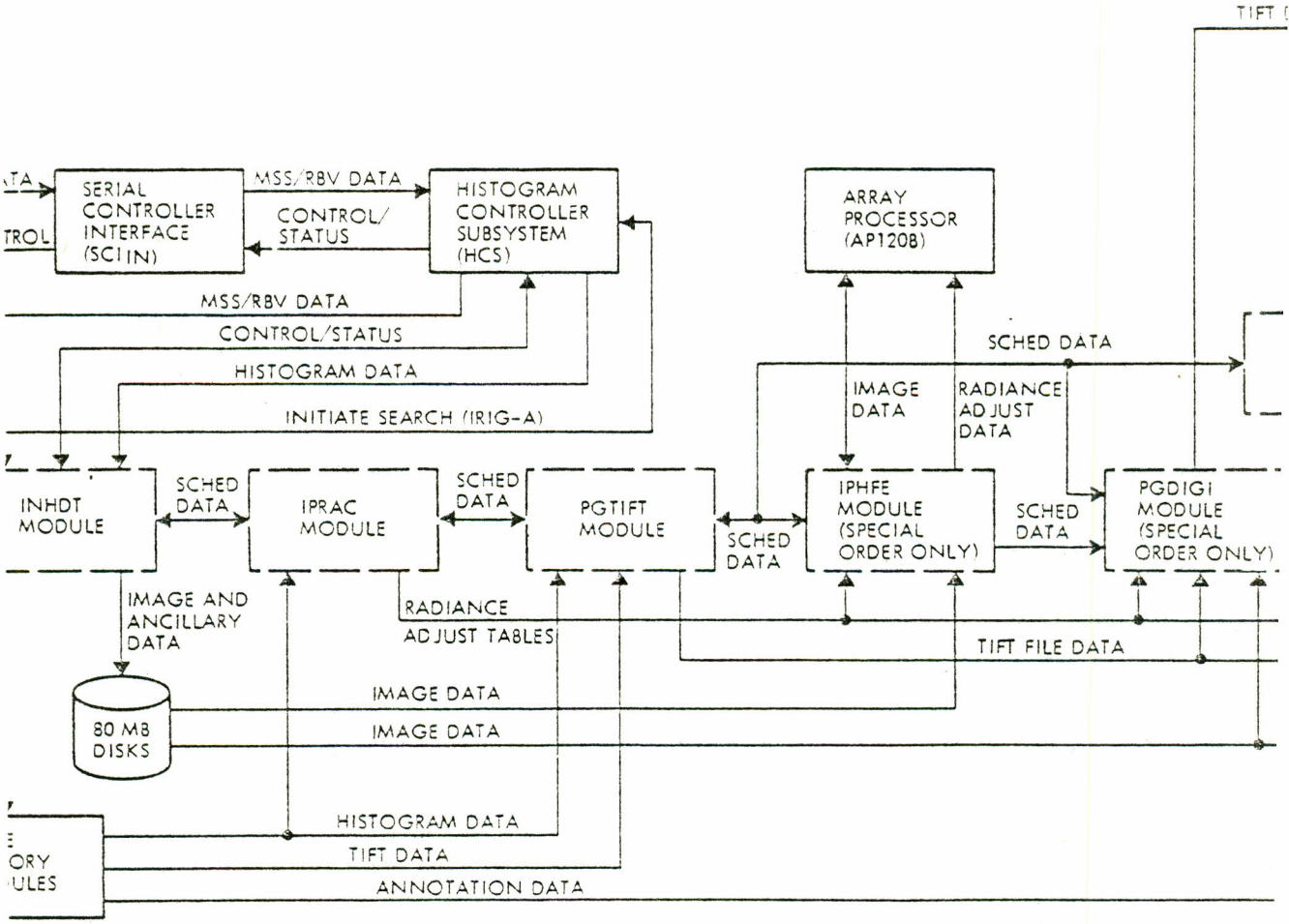
3-3. SYSTEM SETUP

The setup phase is required to initialize EDIPS for the upcoming processing period. If data base changes are required, the DBASE module must be activated before work order cards can be processed by the WOCPROC module. If no changes to the data base are required, the DBASE module is bypassed as shown on Figure 3-1, and the WOCPROC module is activated.

The system data base is maintained on a disk file and consists of both dynamic and static parameters. The dynamic parameters (film frame number, etc.) change during and as a consequence of processing, while static parameters (film gap lines, etc.) affect processing, but remain constant during processing. The static parameters change only through use of the DBASE module. As discussed in the previous paragraph, the START module automatically loads a set of data base parameters that are always stored in a permanent disk file into core and initializes the dynamic parameters. This becomes the in-core data base and the dynamic parameters are automatically updated during processing. Regardless of how many changes are made to the in-core data base, the data base stored on disk remains unchanged unless specifically modified by the operator using one of the DBASE module options. Whether modified or not, the latest values in the data base disk file become the initial values that are loaded into core when the START module is again activated.

The DBASE module is activated by means of the operator's CRT terminal when an ACTIVATE DBASE command is entered. Data base changes may then be entered by either the card reader or the CRT terminal. If both devices are available a message is displayed on the CRT to indicate that the operator must specify which device is to be used. DBASE can then be executed and changes entered into the data base.


TO PERIPHERAL DEVICES
REAL-TIME MONITOR MODULE
LINE PRINTER
WOCFILE AND TEMPWOC
80 MB DISK
W.O. DATA
HDT
TAPE IN
HIGH DENSITY TAPE RECORDER (HDTR)
MSS/
HDT
DEVICE COMMANDS
DATA BASE PARAMETERS
W.O. DATA
INMOUNT MODULE
SCHACT
START MODULE
DBASE MODULE (OPTIONAL)
WOCPROC MODULE
SCHED MODULE
SCHED DATA
INSRCH MODULE
SCH DAT
CRT TERMINAL DATA
CRT DATA
CRT DATA
GLOBAL COMMON DATA
NON- AND HISTO DATA
CRT DATA
ACTIVATE START
DATA BASE CHANGE
OPERATOR'S CRT TERMINAL (ADM-3)
SCHED ACTIVATE
DATA BASE CHANGE/ OUTPUT DATA
HARDCOPY DATA
WOC DATA
HARD COPY PRINTER
WORK ORDER CARDS
WOC IN
CARD READER
DATA BASE TRANSFER
80 MB DISK
DATA TRANSFER
CORE MEMORY
SYSTEM DATA BASE FILE
GLOBALOO
LEGEND:
SOFTWARE MODULES
HARDWARE MODULES


TIFT
TA
TROL
SERIAL CONTROLLER INTERFACE (SCIIN)
MSS/RBV DATA
CONTROL/ STATUS
HISTOGRAM CONTROLLER SUBSYSTEM (HCS)
ARRAY PROCESSOR (AP120B)
MSS/RBV DATA
CONTROL/STATUS
HISTOGRAM DATA
INITIATE SEARCH (IRIG-A)
SCHED DATA
IMAGE DATA
RADIANCE ADJUST DATA
INHDT MODULE
SCHED DATA
IPRAC MODULE
SCHED DATA
PGTIFT MODULE
SCHED DATA
IPHFE MODULE (SPECIAL ORDER ONLY)
SCHED DATA
PGDIGI MODULE (SPECIAL ORDER ONLY)
IMAGE AND ANCILLARY DATA
RADIANCE ADJUST TABLES
TIFT FILE DATA
IMAGE DATA
80 MB DISKS
IMAGE DATA
HISTOGRAM DATA
ORY
ULES
TIFT DATA
ANNOTATION DATA

30400-6009-RU-00

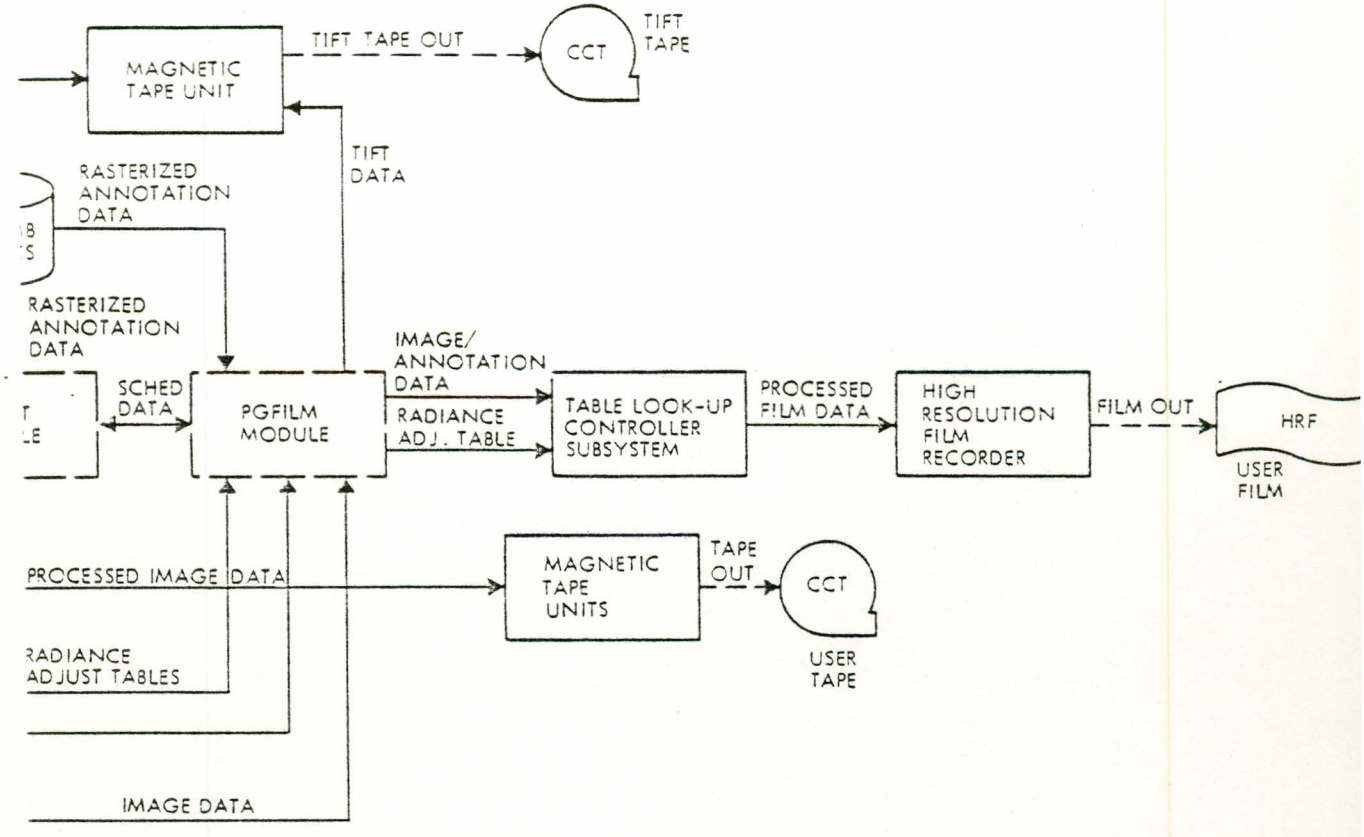


Figure 3-1. EDIPS Processing Flow Diagram

Once the data base is established, all work order data is entered into the system by activating the WOCPROC module. This module must be activated during the setup phase for each processing period, and may be activated any number of times during the processing period to enter additional work orders. A maximum of 100 work orders may be entered during setup, and an additional 100 may be entered in any desired increments during the processing period. The work orders may be entered from either the card reader or the CRT terminal. The data items appearing on the work orders specify the input medium (HDT or CCT), algorithms to be applied, algorithm order where applicable, processing parameters, output medium (CCT or film), and output format and recording density for CCT products.

The WOCPROC module is activated when the operator enters the ACTIVATE WOCPROC command on the operator's CRT terminal. Work orders may then be entered by either work order cards read in through the card reader or through the CRT terminal. If both devices are available, the operator must specify which device is to be used before proceeding. Once the input device is established, the WOCPROC module takes the work order inputs and uses them to create a work order buffer. A copy of the buffer is made for each set of up to three work order cards in an order, and stored in either WOCFILE or TEMPWOC files on disk memories. The first 100 orders entered are placed in WOCFILE, while up to 100 additional orders entered during processing are placed in the TEMPWOC file. Each time the work orders in WOCFILE are completed, those in TEMPWOC are automatically transferred to WOCFILE for processing. When TEMPWOC has been emptied, a message is displayed on the operator's CRT terminal to indicate this condition.

The WOCPROC module checks the validity of all work order parameters entered, and also that card sets are inputted in the proper order. If an error is detected, the operation is terminated and an error message is displayed on the CRT terminal. None of the work orders in this submittal can be entered into the system. The operator must therefore correct the error, activate WOCPROC again, and resubmit the entire card deck.

When work orders are entered by cards or through the terminal, the operator may request a review of the work order data by means of the CRT display or the line printer. The operator may then accept, modify, or abort each work order at his discretion. After all work orders are properly entered into the system, the setup phase is complete, and the image processing functions may then be initiated.

3-4. IMAGE PROCESSING

3-5. SCHEDULER. All processing operations are controlled by the scheduler (SCHED) module based on work order entries

stored in the WOCFILE disk memory. Once the WOCFILE has been generated by the WOCPROC task, and the scheduler module is activated, it automatically operates on each work order to cause specific processing tasks to be performed through the use of various application modules. When all work orders in WOCFILE have been completed, the scheduler transfers the work orders from the TEMPWOC file to WOCFILE, and processing is again resumed. After completing the work orders in both files, the system idles awaiting the next operator action, and an EDIPS IDLE message is displayed on the CRT terminal. The operator may then enter additional work orders, if required, or terminate the processing period.

Once the scheduler begins the processing operations, the only means for operator intervention is through use of the STOPFLOW task. This task terminates the work order processing prior to normal completion of the processing period. All work orders currently scheduled to be completed, and all unprocessed work orders are then marked as having been processed. If there are any additional work orders in TEMPWOC, they too will be discarded. Just as for normal completion of work orders, the message EDIPS IDLE is displayed on the operator's terminal, and the system idles while awaiting the next processing period to be initiated, or a terminate command to be issued.

The scheduler module is activated by the ACTIVATE SCHED command applied from the operator's CRT terminal. The scheduler then selects work orders from the WOCFILE and enables the application modules in the sequence (left-to-right) shown in Figure 3-1. Interface between the scheduler and all application modules is provided through a subroutine module identified as SCHACT. This module is used by all application modules to inform the scheduler when their specific processing tasks have been completed. They each return five arguments to the scheduler which are then stored in the GLOBALOO core memory. These are defined as follows:

a. Identification of the task performed.

b. Identification of the work order buffer used by the task during its processing.

c. Identification of the disk controller used.

d. Identification of the disk unit used.

e. Identification of the termination code used by the task.

When all five arguments are given by the active application module, the scheduler then resumes operation by scheduling the next module.

3-6. INMOUNT MODULE. The processing sequence begins with the INMOUNT module. When enabled by the scheduler, the INMOUNT module instructs the operator to mount a HDT and then checks the availability of the required hardware components (HDTR, SCI and HCS) via the device status array. If a hardware failure is detected, the HDTR/SCI units are placed off line, and an abort message is displayed on the operator's CRT terminal. However, if no hardware failure is detected, an operator continue message is displayed and the tape is moved forward until five distinct IRIG seconds are read. If more than 500 feet of tape passes through the HDTR before this requirement is met, the work order is aborted and the HDT is rewound. An abort message is then displayed on the operator's CRT terminal.

3-7. INSRCH MODULE. The processing sequence continues with the INSRCH program. This module performs all the functions necessary to mount the high density tape (HDT) into the HDTR, and initiate search for the IRIG-A time supplied by the work order. INSRCH starts by issuing the tape-mount message to the operator's CRT terminal. When the HDT is mounted and ready, a search command is issued to the serial controller interface (SCI) unit via the histogrammer controller subsystem (HCS). The SCI unit causes the HDTR to perform a high-speed search of the tape to a time specified by the IRIG-A code. The search is performed in either forward or reverse direction at a speed of 240 ips, and requires approximately eight minutes (worst case) to search a 9200-foot tape. The SCI compares the time specified by the program to the IRIG-A time code recorded on channel one of the tape. When the correct code is found, the SCI causes the HDTR to stop tape motion just before the header major frame appears. The scheduler is then informed that the task is completed, and the INHDT module is enabled to initiate the next processing operation. The INSRCH module is capable of handling two such work orders simultaneously, while returning them to the scheduler in the order of search completion.

The INSRCH module also monitors all processing operations and generates status messages to the scheduler for each processing step in order to maintain a processing log. Error messages are immediately displayed on the operator's CRT terminal for further operator action.

3-8. INHDT MODULE. The INHDT module is the third application module to be enabled by the scheduler in the processing sequence. This module reads MSS/RBV data from a HDT, separates the image from non-image data, and places the former in 80 MB disk storage and the latter in core storage buffers. The INHDT module also extracts histogram data from the histogrammer controller subsystem (HCS) and stores this data in core memory. The INHDT module starts by initiating a read command to the SCI causing tape data to be read into the system at a nominal tape speed of 30 ips. This rate permits

an entire 9200-foot tape to be entered in approximately 60 minutes. The INHDT module compares the scend ID from the header section of the tape with that specified on the work order and, if correct, enters the data into storage via the SCI and HCS units. The image and ancillary data are entered into the 80 MB disk memory unit while the header, annotation, and trailer data are all stored in core memory locations specified by the scheduler. The INHDT module also controls the HCS by specifying the start and stop positions on a scan line where histogramming is to be performed. The histogram is also adjusted to remove the leading and trailing fill counts and overlap marks. The resulting histogram data are then transferred to specific locations in core memory.

As each image is processed, quality data is summarized and stored in core memory. As each scene or subscene is processed and stored, the image disk is passed on to the scheduler to permit further processing by the next application module (IPRAC).

The INHDT module also monitors all processing operations and produces status messages for each processing step in order to generate a processing log. Error messages are immediately displayed on the operator's CRT terminal for all error conditions.

3-9. IPRAC MODULE. The IPRAC module performs all required calculations applied to the histogram data for each MSS band and RBV subscene. These include:

a. Calculation of the mean and standard deviations of pixel values for each histogram. When specified on the work order card (user option), a hardcopy printout of the resulting histogram data is generated for each film output product. A hardcopy printout is also provided for all CCT output products.

b. Calculation of the radiance adjustment tables for implementing the contrast stretch and haze removal algorithms. By means of the calculated radiance table, the contrast stretch function automatically adjusts the overall and specific characteristics of image data to recover sensor data located in saturated or undersaturated regions. In order to see subtle variations in brightness within an image, the image contrast is stretched so that pixel gray levels are separated as much as possible to fill the dynamic range of the display medium (i.e., 0-255). The haze removal function simply corrects the image data for scattering effects (haze) by removing a fixed radiance bias from each MSS band or RBV subscene. For special order processing, the contrast stretch and haze removal functions may be implemented singly, in either order, or not at all as specified by the user through work order card entries.

The radiance table computations are based on specific control parameters that are either specified on applicable work order cards or retrieved from storage in the data base. The data base parameters are spike/tail values which are automatically applied for contrast stretch and haze removal bias calculations in the pipeline processing mode. By use of the spike/tail algorithm (described in Section V) and histogram data, minimum/maximum intensity values are computed for construction of the radiance adjustment table. For special order processing, the required minimum/maximum values are supplied directly from work order cards, or by default are computed from the data base-supplied spike/tail values as previously described, or from data base-supplied haze removal bias. A description of the minimum/maximum and spike/tail algorithms is provided in Section V.

By use of the control parameters described above, the IPRAC module computes a 256-element pixel radiance mapping table which stores an adjusted output intensity for each allowable input intensity (0 to 255 maximum). This adjustment is based on one of the following:

a. A linear contrast stretch of minimum/maximum intensity defined by:

$$\text{OUTPUT} = \frac{\text{INPUT} - \text{MINIMUM}}{\text{MAXIMUM} - \text{MINIMUM}} \times \text{CONSTANT}$$

and truncating any values below 0 to 0 and above constant to constant. Constant is 255,127, or 63, for 8,7, or 6 bit pixel values, respectively.

b. A haze removal shift defined by:

$$\text{OUTPUT} = \text{INPUT} - (\text{HAZE REMOVAL BIAS})$$

and truncating any values below 0 to 0.

The resulting radiance adjustment tables are supplied to the PGFILM, PGDIGI and IPHFE modules for performing the required enhancement calculations. For special order processing, the application of the radiance adjustment table determines the order in which the image enhancement algorithms are implemented. Application of the table to the edge enhancement (IPHFE) module implies that contrast stretch and/or haze removal is performed before edge enhancement. Application of the table to either the PGFILM or PGDIGI module, but not to the IPHFE module, implies that edge enhancement is performed first, then contrast stretch and/or haze removal.

The IPRAC module also generates processing status data for each operation performed in order to update the processing log.

3-10. PGTIFT MODULE. The PGTIFT module prepares a tape record for the transient image file tape (TIFT) consisting of data items extracted from the input data stream, together with histogram and tape status data for each band and subscene. These files are then recorded on computer compatible tape by the PGDIGI and PGRAST modules.

When activated by the scheduler, the PGTIFT module extracts the histogram, tape status, and HDT description data from the scene buffer in core memory for each MSS band or RBV subscene processed. A TIFT record file is then created for each band or subscene and status data is returned to the scheduler after each significant processing step is performed. When the PGDIGI or PGRAST modules are enabled, the TIFT files are extracted from the PGTIFT module and recorded on tape.

The PGTIFT module also generates status messages for each significant processing step for the processing log.

3-11. IPHFE MODULE. The IPHFE module is utilized only for special order processing in order to control the high-frequency edge enhancement function. This function improves the visibility of fine structure in an image by means of a variable box filter. The filtering process boosts the proportional contribution of high-frequency spatial variations in the output imagery thus enhancing the edges. A radiance adjustment of the input data may also be performed, on option, by use of the radiance adjustment table generated by the IPRAC module. The application of the table is determined by the work order - specified sequence in which edge enhancement is to be performed with respect to the contrast stretch and/or haze removal functions. Application of the table to the IPHFE module implies that contrast stretch and/or haze removal is performed before edge enhancement. The table data supplied from IPRAC would then be radiance adjusted data in this instance. However, application of the table by either the PGFILM or PGDIGI module, but not to the IPHFE module, implies that edge enhancement is performed first.

The IPHFE module is activated by the scheduler in response to special order work requests. Image data is extracted from the image disk and transferred to the array processor. In like manner, either radiance adjusted or non-radiance adjusted data is also transferred to the array processor and the image enhancement algorithms are implemented through use of the APHFE microcode subroutine. (A description of the algorithm is provided in Section V.) APHFE utilizes the table data to effect the conversion of integer pixel data to a normalized floating format within the array processor. A low-pass box filter of size N lines by M pixels is then

passed over the input scene, one full scan line at a time, from left to right, then top to bottom. The resulting enhanced data is then converted from the floating point format to an integer format, and transferred back to the disk storage to await further processing.

The IPHFE module reports all processing status, exception conditions, and process termination information to the scheduler. The processing status information is also entered into the processing log.

3-12. PGDIGI MODULE. The PGDIGI module is enabled only for special order processing when work order requirements specify that image data is to be digitally recorded on computer compatible tape rather than on film. Contrast stretch and haze remove enhancement algorithms may also be implemented by this module if specified on applicable work orders. The TIFT file is also updated with CCT dependent data and outputted to the magnetic tape unit to produce the TIFT.

The PGDIGI module is activated by the scheduler in response to a work order request for a CCT output. Image data is extracted from a location in disk memory specified by the scheduler. The image data is read in logical blocks of MSS band interleaved by cylinder, or RBV subscene sequential. If the haze removal and/or contrast stretch options are selected, the radiance adjustment table supplied by the IPRAC module is used to implement the algorithms for performing the associated functions.

Based on work order specifications, the PGDIGI module causes the magnetic tape unit to record the processed image data on CCT at a density of either 800 or 1600 BPI. By user request, the MSS CCT data can be output in either band sequential (BSQ) or band-interleaved-by-line (BIL) formats. The RBV CCT data is output in subscene sequential format.

The PGDIGI module provides status data to the scheduler for each significant processing step performed. Status and error messages are also generated for entry into the processing log, and error messages are immediately displayed on the operator's CRT terminal. Quality and processing data are also supplied to the line printer for each output produced in order to provide a hardcopy printout.

3-13. PGRAST MODULE. The PGRAST module rasterizes the top, bottom, and side annotation data, as well as tick marks and gray scale data obtained from input tapes. The rasterized data are subsequently recorded on the borders of high resolution film by the HRFR.

When activated by the scheduler, the PGRAST module extracts the annotation data from a specific core memory file specified by the scheduler, rasterizes the data, and transfers

it to disk memory units. The top and bottom annotation and tick marks are written into a specified image file on an 80 MB disk, while the left and right tick marks are stored on the system 80 MB disk. All bands of an MSS scene use the same annotation file, whereas each RBV subscene has a unique file.

Status data is supplied to the scheduler for each significant processing step performed. Status and error messages are also generated for entry into the processing log, and error messages are also immediately displayed on the operator's CRT terminal.

3-14. PGFILM MODULE. The PGFILM module performs all functions required to produce the desired high-resolution film product for both the pipeline and special order processing modes. These functions include control and status monitoring of the HRFR; control of haze removal and contrast stretch operations; control of data transfer between the disk units, table look-up/controller subsystem (TCS), and HRFR; and update and generation of the TIFT.

When activated by the scheduler, the PGFILM module reads in logical blocks of either MSS or RBV image data from locations in disk memory specified by the scheduler. PGFILM also extracts the rasterized annotation data from disk units; the top and bottom annotation and tick marks are read from the image disk while the left and right tick marks are read from a separate 80 MB disk. The rasterized annotation data is linked to the image data in a data chain and then outputted to the table look-up/controller subsystem. The radiance adjustment table is concurrently received from the IPRAC module and also outputted to the TCS to perform haze removal and contrast stretch functions.

Based on the radiance adjustment data, the TCS implements the haze removal and contrast stretch algorithms thereby enhancing the input image data which is then applied to the HRFR. Under control of the PGFILM module, the HRFR produces a black and white, negative or positive 9-1/2-inch film product. The processing status of the HRFR is also monitored to determine data late errors, low film, modulated bias limit warnings, and master fault warnings. If any of these errors occur, an error message is generated by PGFILM and immediately displayed on the operator's CRT terminal and also entered into the processing log.

On command from the scheduler, the PGFILM module also updates any HRFR-dependent TIFT data in the TIFT file. The TIFT file data is then recorded on CCT by the magnetic tape unit.

Processing status messages are supplied to the scheduler for each significant processing step performed. These status messages are also entered into the processing log.

3-15. EDIPS TERMINATION

Upon completion of the last desired processing period, the WRAPUP module must be activated. This module terminates the EDIPS modules residing in core and also saves certain data required for the next EDIPS run.

The operator enters the ACTIVATE WRAPUP command from the operator's CRT terminal. The WRAPUP module queries the operator if a hardcopy printout is desired of the Statistical Error Monitor Service (SEMS) and provides it if requested. The SEMS summary presents error statistics for each peripheral device. WRAPUP also prompts the operator to activate the LOG module if a hardcopy printout of the processing log is desired. The processing log (LOGFILE) contains status and error messages supplied from all software user modules.

3-16. HISTOGRAM GENERATION

For each MSS band or RBV subscene a histogram (pixel radiance values in digital counts versus frequency of occurrence) is generated automatically. A table look-up scheme is used to generate this pixel level histogram. This method uses the input pixel value (one byte or 8 bits of data per pixel) as the table address and the corresponding table entry as a counter (i.e., keeping count of the number of times that pixels of the same value occur).

The histogram table size (per MSS band or RBV subscene) is 256 words by 32 bits, one word for each pixel level. Every single pixel of each scan may be used in calculating the histogram.

The histogram data is retained within the system and used for contrast adjustment during later processing stages. The histogram data from each MSS band and RBV subscene is recorded on the TIF tape and may also be obtained in hard copy print form.

The diagram in Figure 3-2 illustrates what takes place within the histogrammer controller subsystem during generation of the histogram. Data is transferred to the HCS in 16-bit blocks. The HCS will check incoming data for a known pattern 11101101 in the 6th byte of the present scanline block transfer to determine if it is image data and then turn on the histogrammer. The HCS also has a pair of counters which control the histogramming start and stop times. These counters may be used to alternately histogram and not histogram predefined portions of each scanline. The portions of the scanline to be histogrammed is defined as either:

a. Every Kth pixel, with K a programmable constant, or

b. N pixels after M pixels from the beginning of each scanline.

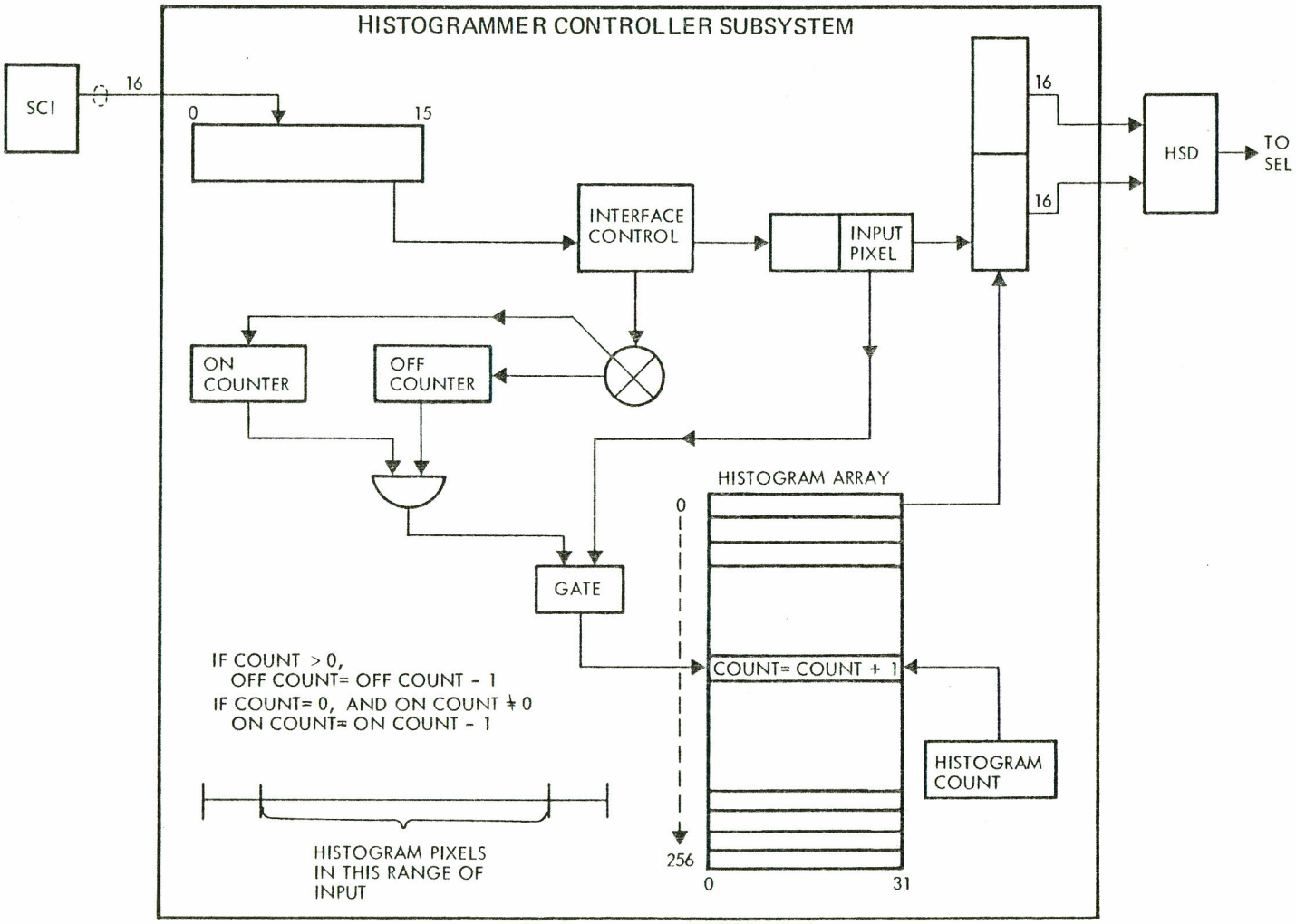


Figure 3-2. Overview of Histogrammer Controller Subsystem

Table address is determined by the input pixel value when histogramming is taking place. The count in the selected register is then updated. When a complete MSS band or RBV subscene has been histogrammed the histogram array may be transferred to the computer core memory. When this is done the registers of the array are automatically cleared to zero for the next run. Data are transferred to the high speed data interface (HSD) in blocks of 32 bits.

3-17. TABLE LOOK-UP

The look-up table consists of 256 bytes (8 bits/byte) of data. This array of data is referred to as the radiance mapping table. It is used in the table look-up/controller subsystem (TCS) as shown in Figure 3-3. For each allowable input intensity (0 to a maximum of 255), an adjusted output intensity is calculated.

Data arrives at the TCS in blocks of 32 bits. The data handling mechanism here is similar to that of the HCS in that the TCS first checks for the presence of image data before enabling the table look-up logic. The TCS also has a pair of counters used to control the range over which image data is to be adjusted. The image data (pixel-by-pixel) then index the table look-up array and the value array must be loaded before output transfer takes place, with pixel values previously calculated as noted above.

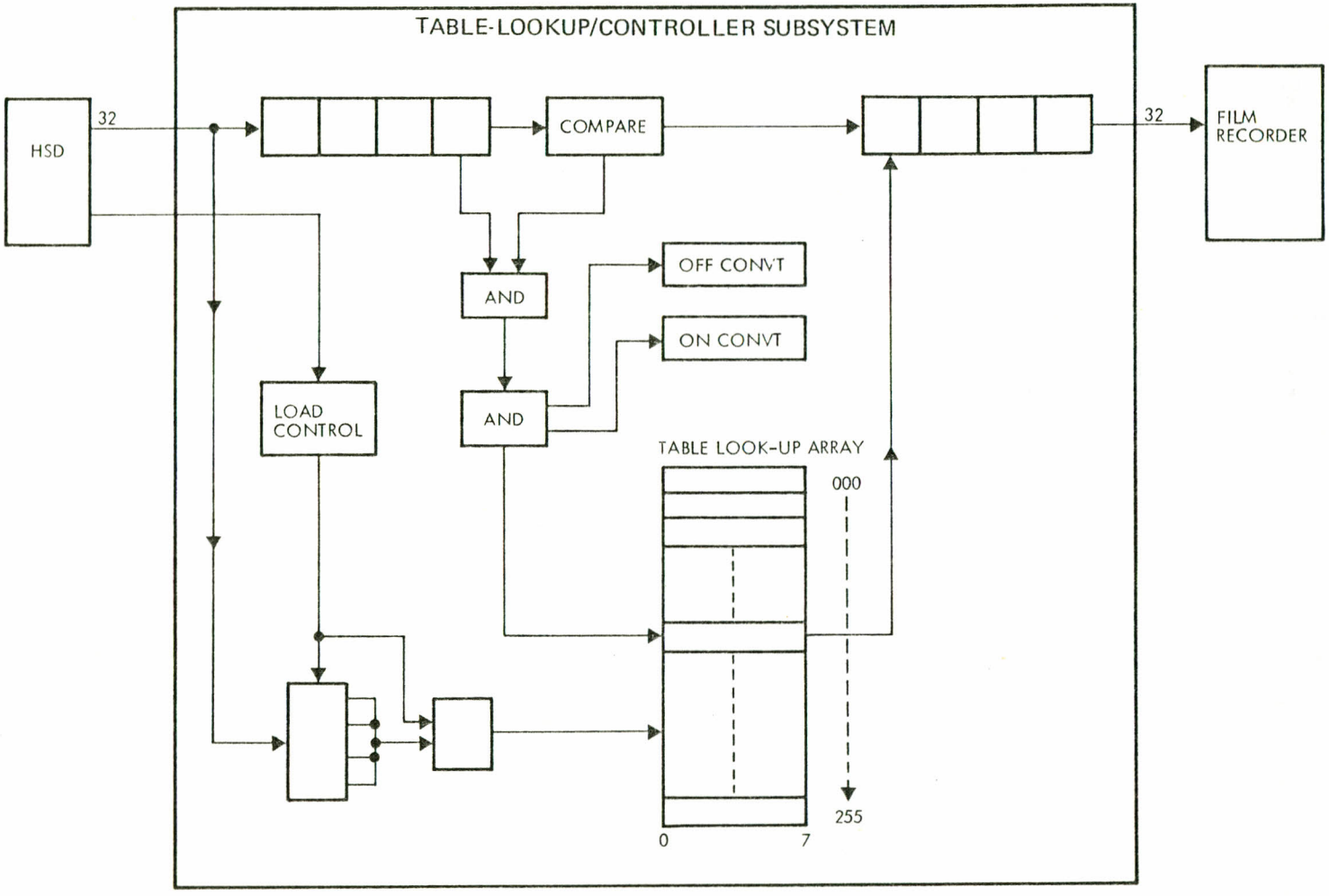


Figure 3-3. Overview of Table Lookup/Controller Subsystem

SECTION IV

SYSTEM USE

This section describes the EDIPS operational procedures, and indicates user interface with the system. The operator actions required for system operation are summarized. For detailed, step-by-step operating procedures refer to the EDIPS Operation and Maintenance Manual.

4-1. OPERATIONAL PROCEDURES

Figure 4-1 is an EDIPS timeline which illustrates both typical and possible operational procedures. Although the scenario illulstrated assumes that the computer system starts in a power-down mode, this is not always the case. Obviously, depending upon the starting point, certain actions (e.g., power-up, load RTM) might not be required during system initiation. System initiation is an operator-performed function using SEL standard procedures and software. Start-up is accomplished using module START, and is always required at the beginning of EDIPS operation.

The basic unit of EDIPS operation is a processing period. A processing period must be initiated by a set-up phase in which, at a minimum, Module WOCPROC is activated to enter work orders into the system. If changes to the data base are desired for this processing period, Module DBASE must be activated. Module DBASE can only be used during a set-up phase; if used, it must always precede Module WOCPROC. That is, if the data base is to be modified for a given processing period, the data base change must be entered prior to entering the initial work order data for that period. As indicated in Figure 4-1, additional work orders can be entered at any time during a processing period; however, data base changes can be made, at most, only once at the beginning of the processing period. Data base changes made for one processing period carry over to subsequent periods unless remodified.

Changes to the film roll/frame number, independent of the actual HRFR low film warning, can be made during the set-up phase of a processing period using Module FILMCH. Module FILMCH can be activated only during a set-up phase; however, it may be activated at any point during the set-up phase (i.e., before or after WOCPROC, before or after DBASE).

The beginning of the processing step within a given processing period is initiated by the operator activating Module SCHED (EDIPS scheduler). SCHED automatically activates the appropriate application modules in the proper sequence to process each work order entered.

In addition to WOCPROC, Modules LOG and DEVSET are available for operator activation at any time during a processing period to perform special functions. LOG provides the capability to display a selected portion of the LOGFILE (processing log) on the CRT. DEVSET allows the operator to on-line or off-line, to the EDIPS software, certain peripheral, devices, both standard or EDIPS-special in nature.

A processing period is completed when either of the following conditions occur:

a. All of the work orders entered for this period (i.e., during set-up plus any entered during the period) have been processed (normal completion).

b. The operator initiates premature completion by activating Module STOPFLOW. Processing on work orders already in progress will be terminated and any remaining work orders will be discarded (i.e., not processed and permanently removed from the work order queue).

When either of the above completed conditions occur, an "EDIPS IDLE" message is sent to the operator's console and the system idles awaiting the next operator action (initiate next processing period or terminate).

Upon completion of the last desired processing period, Module WRAPUP must be activated to perform the EDIPS Termination Phase. WRAPUP allows the user to select various optional system outputs (Processing Log print, SEMS, etc.), and performs required processing and file termination actions.

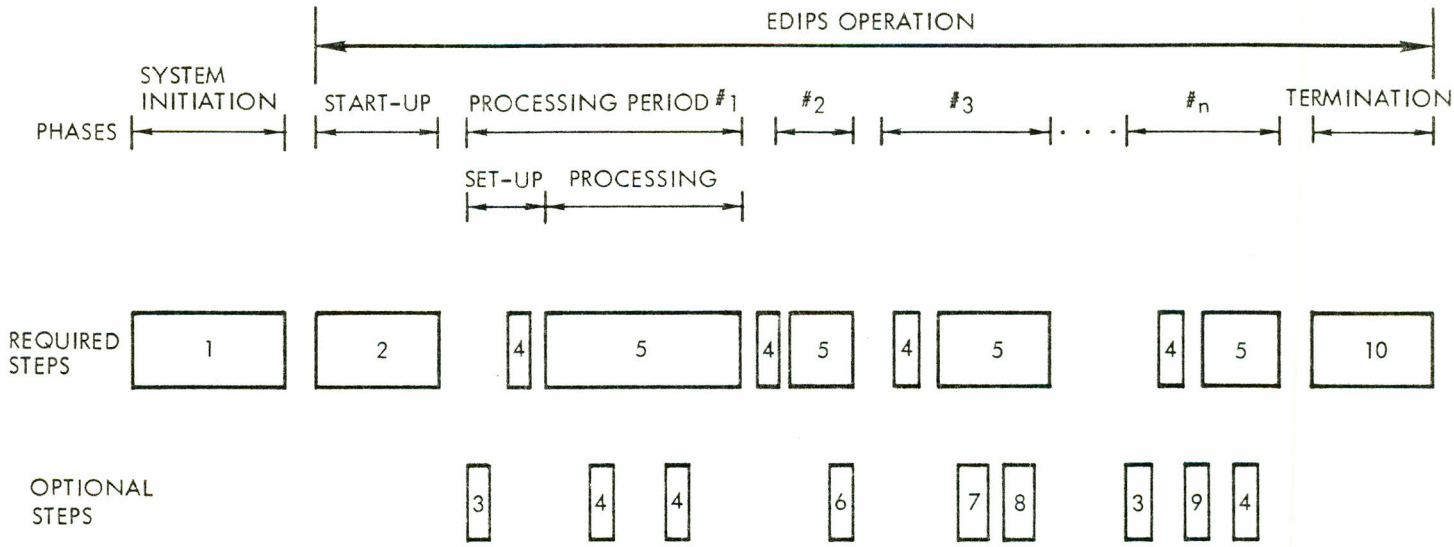
The EDIPS devices available for direct operator interaction are the operator's console (OC), an interactive CRT, a card reader, and a line printer. When employed, the CRT is used solely in a teletypewriter mode.

4-2. SYSTEM INITIATION

There are three standard SEL procedures for initiating the system: COLD START, WARM START, and RESTART. The RESTART procedure will be the one commonly used on a day-to-day basis for the EDIPS. RESTART is a bootstrap process requiring available disk drives be turned on and in the ready state. After the disk drivers are ready, the system is bootstrapped and is ready to activate the EDIPS software.

4-3. START-UP

The startup phase is performed entirely by the operator interacting with Module START. Startup is the mandatory first step in each EDIPS "processing day" which is defined as the time period between running Module START and Module WRAPUP. This implies that Module START must be used regardless of whether the system has been powered down, or whether any other software has executed since Module WRAPUP was run on the previous "processing day."



DEFINITION OF OPERATIONAL STEPS

STEP	ACTIONS	APPLICABLE MODULE	APPLICABLE SECTION (S)
1	POWER UP SYSTEM; MOUNT DISKS; PERFORM INITIAL PROGRAM LOAD (RTM)		4-2
2	CHECK DEVICES; LOAD EDIPS MODULES; INITIALIZE CORE; READ IN DATA BASE AND INITIALIZE FILM ROLL AND FRAME NUMBER	START	4-3
3	MODIFY DATA BASE PARAMETERS	DBASE	
4	ENTER WORK ORDERS	WOCPROC	
5	PROCESS WORK ORDERS	SCHED + APPLICATIONS	
6	PREMATURELY TERMINATE PROCESSING PERIOD	STOPFLOW	4-4 & 4-5
7	DISPLAY SELECTED PORTION OF PROCESSING LOG ON CRT	LOG	
8	ON-LINE/OFF-LINE A PERIPHERAL DEVICE	DEVSET	
9	CHANGE FILM ROLL/FRAME NUMBER	FILMCH	
10	TERMINATE EDIPS OPERATION	WRAPUP	4-6

Figure 4-1. EDIPS Processing Timeline

The operator enters the command ACTIVATE START on the operator's console and then performs a sequence of interactions to accomplish the following:

- Check availability of, and select peripheral devices, both standard and special
- Select roll and frame number of film
- Assign MT unit to TIFT
- Assign tape label number
- Signal that startup is successful and that processing can begin.

EDIPS is capable of operating in a degraded mode when less than the full complement of peripheral devices are present. Naturally, there are processing limitations based on which devices are unavailable, and there is a minimum configuration below which EDIPS cannot be operated. Table 4-1 indicates the processing limitations imposed by devices not being available.

The minimum configuration below which EDIPS cannot be operated is as follows:

a. Each of the following:

1. Operator's Console
2. At least one 80 MB disk and controller
3. TIFT (one Magnetic Tape Unit)
4. Card Reader or CRT

b. Plus at least one out of the two following combinations:

1. One HDTR/SCI and HCS; LP and one MTU or the TCS/HRFR
2. One MTU; TCS/HRFR

Module START cannot check the availability of the card reader (CR), MTUs, HDTRs, or the interactive CRT. Consequently, these devices will always be assumed to be present by START. If any of these devices are not present or not desired to be used during the processing, their availability should be changed using module DEVSET (section 4-5d) immediately after module START is completed.

Table 4-1. Device Dependent Processing Limitations

Device Unavailable	Implied Conditions	Processing Limitations
CR	CRT Must Be On	1. Data Base changes via CRT only (DBASE) 2. WOC Entry must be via CRT only (WOCPROC)
LP	Only Film Products Provided	1. No CCT summary print possible, hence no CCT products 2. Suppress WOC Print (WOCPROC) 3. Suppress Histogram Print (IPRAC) 4. Suppress Print of LOGFILE (LOG) 5. Suppress Data Base Print (DBASE)
CRT	CR Must Be On	1. WOC entry is through CR only (WOCPROC) 2. No display of LOGFILE (LOG) 3. No entry of Data Base Parameters via CRT (DBASE)
AP		1. No Edge Enhancement performed
HDTR/SCI or HCS	Only CCT Input Allowed	1. No HDT Input allowed
CCT Tape Unit	Only Film Products Provided Only HDT Input Allowed	1. No CCT output products 2. No CCT input allowed
HRFR/TCS	Only CCT Products Provided	1. No Film Products provided

4-4 SET-UP

The basic unit of EDIPS operation is a processing period. A processing period must be initiated by a setup phase in which, at a minimum, module WOCPROC is activated to enter work orders into the system. Also, if changes to the data base are desired, module DBASE must be activated. Module DEBASE, if used, must always precede WOCPROC. If changes to the film roll/frame number are desired, module FILMCH must also be activated. FILMCH can be activated before, after, or between modules DBASE and WOCPROC.

a. DBASE

The EDIPS data base contains both dynamic and static parameters. The dynamic parameters (e.g., film frame number) change during, and as a consequence of the processing. The static parameters affect the processing, but remain constant during the processing. Table 4-2 lists the static parameters in the data base which may be changed by module DBASE.

A set of data base parameter values is always stored in a permanent file on disk. Module START automatically loads this set of values into core and initializes the dynamic parameters. This becomes the "in-core" data base. The dynamic parameters are automatically updated during processing. The static parameters change only through using DBASE, and are cumulative in nature (i.e., the in-core data base reflects the sum total of all changes made since the Start-up phase).

Regardless of how many changes are made to the in-core data base, the data base on disk remains unchanged unless specifically modified by the operator using one of the options in DBASE. Whether modified or left unchanged, the latest values in the data base disk file represent the initial values loaded into core to begin the "next day's" processing (i.e., the next time module START is activated).

The operator enters the command ACTIVATE DBASE on the operator's console (OC). As discussed earlier, the use of DBASE is restricted to the set-up phase of a processing period. It cannot be used during the processing phase of a processing period. If activated during the processing phase, DBASE will exit without executing after displaying the following message on the OC:

DBASE ABORT-SCHED BUSY

The operator must wait until the next set-up phase to activate DEBASE and submit the data changes.

For DBASE to execute, either the CRT or card reader (CR) must be available. Upon activation, DBASE checks the

Table 4-2. Data Base Static Parameters

Parameter Name	Symbol	Dim	Type	Range	Definition
ANNOTATION-GRAY-LEVEL	IANNOT	-	Binary	0-255	Intensity level of film annotation
NORMAL-FILM-GAP	INORM	(2)	Binary	---	Normal number of film gap lines used between MSS bands or RBV subscenes
SPECIAL-FILM-GAP	ISPEC	(2)	Binary	---	Special number of film gap lines used between MSS bands or RBV subscenes
EE-KERNEL-DEFAULT	KERNDF	(2)	Binary	1,3,5,7,9	KERNDF (1); default number of lines in edge enhancement kernel KERNDF (2); default number of pixels in edge enhancement kernel
POS-NEG-DEFAULT	IPNDF	-	Char.	P,N	Film positive/negative default value
REV-TRUE-DEFAULT	IRTDF	-	Char.	R,T	Film reverted/true default value
HRFR-DLOGE-TABLE-DEFAULT	ILOGDF	-	Binary	1,2,3,4,9	HRFR table default value
CS-UNITS-DEFAULT	ICSDF	-	Char.	P,G	P = Contrast stretch cut-off values specified in 10^{-3}% G = VALUES IN GRAY LEVEL
MINIMUM-CS-CUTOFF-DEFAULT	MNCUTDF	(9)	Binary	0-9999	Default minimum contrast stretch cutoff values if units are P; (1) to (5) MSS; (6) to (9) RBV
				0-255	Default minimum contrast stretch cutoff values if units are G; (1) to (5) MSS; (6) to (9) RBV
MAXIMUM-CS-CUTOFF-DEFAULT	MXCUTDF	(9)	Binary	0-9999	Default maximum contrast stretch cutoff values if units are P; (1) to (5) MSS; (6) to (9) RBV
MINIMUM-SPIKE-DEFAULT	MNSPKDF	(9)	Binary	0-9999	Default spike magnitude criterion minimum cutoff; always in 10^{-3}%; (1) to (5) MSS; (6) to (9) RBV
MAXIMUM-SPIKE-DEFAULT	MXSPKDF	(9)	Binary	0-9999	Default spike magnitude criterion maximum cutoff; always in 10^{-3} %; (1) to (5) MSS; (6) to (9) RBV
HR-BIAS-DEFAULT	IBISDF	(9)	Binary	0-255	Default haze removal bias; (1) to (5) MSS (6) to (9) RBV
PIPELINE-PROCESSING-DEFAULT	IPLDF	-	Binary	0-4	0 = No table look-up 1 = Haze removal only 2 = Contrast stretch only 3 = HR before CS 4 = CS before HR
NUMBER-PARITY-RETRIES	NTRYPR	-	Binary	0-255	Maximum number of retries on a band/subscene if parity errors on a HDT read exceed data base parameter MXPARY

Table 4-2. Data Base Static Parameters (Continued)

Parameter Name	Symbol	Dim	Type	Range	Definition
NUMBER-MISSING-DATA-RETRIES	NTRYMD	-	Binary	0-255	Maximum number of retries on a band/subscene if missing data occurs on a HDT read
PARITY-ERROR-THRESHOLD	MXPARY	-	Binary	0-32767	Maximum allowable parity errors
IMAGE-SEARCH-LIMIT	NSRCH	-	Binary	0-255	Maximum number of scenes to search for correct SCENE ID after reaching read speed following IRIG search
HISTOGRAM-SCALING-FLAG	IHISFL	-	Binary	0,1	0, No scaling on histogram print histogram ordinate (pixel count); 1, scaled to actual maximum % rather than to fixed 100%
PL-MSS-DEFAULT	MPLMSS	(5)	Binary	0,1	0, Band defaults to off; 1, defaults to on
PL-RBV-DEFAULT	MPLRBV	(4)	Binary	0,1	0, Subscene defaults to off; 1, defaults to on
EE-RINGING-CONSTANT	EERING	-	Binary	0-255	Enhanced pixel multiplier; input as value * 100
PRINT-CONTROL-FLAG	PRNT	(28)	Binary	0-255	0 - No debug/monitor print; >0 print provided when modules compiled under option 20; value should always be 0 for operational use
				0-255	Default maximum contrast stretch cutoff values if unit are G; (1) to (5) MSS; (6) to (9) RBV

availability of these two devices and takes one of the following actions:

1. If neither of the devices are available, the operator will be notified on the OC that DBASE must abort due to no input device being available. DBASE will then abort. At least one of the devices must be brought online and DBASE activated again to enter the desired changes or the current in-core data base must be used.

2. If only one of the devices are available, the operator will be notified on the OC which device (CR or CRT) must be used.

3. If both of the devices are available, DBASE will query the operator and allow him to specify via the OC which device is to be used.

Assuming that either condition 2 or 3 occurs, DBASE can be executed and changes entered to the data base. DBASE is controlled through a set of directives listed below.

DIRECTIVE	MNEMONIC	DEFINITION
RESTORE	RE	Load data base from disk file into core
MODIFY	MO	Changes to present in-core data base follow
SAVE	SA	Replace data base in disk file with present in-core values
PRINT	PR	Print in-core data base values on line printer
EXIT	EX	End of DBASE input

The RESTORE directive causes the present in-core static parameter values to be replaced by the values residing in the disk file. This often is a desired end state in itself or represents the most convenient starting state for new modifications. The MODIFY directive is the only one which requires additional data (i.e., the modified parameters and their new values) to be entered. Obviously, the SAVE directive is the vehicle by which the operator modifies the data base in the permanent disk file as discussed previously. An EXIT must always be given as the final directive.

If the interface device is the CR, the DBASE card deck must contain one directive per card, the directives must be entered in the desired order of performance, and the parameter change cards must follow immediately after the MODIFY directive card. Only the directive mnemonic (i.e., MO, PR, etc.), need be entered and begins in Card Column 1. The parameter change cards are entered in a free-field format using Columns 1 to 70. Parameter changes are entered using the parameter symbols from Table 4-2 (e.g., IANNOT, INORM, etc.). Multiple parameters, separated by commas, may be entered on the same card and multiple cards entered, if

necessary. The card deck set-up to accomplish a MODIFY and PRINT is illustrated below:

```
Card                                          7
Column      1 2 3 4 5 6 . . . . . . . . . . . 0
            M 0
            I A N N O T = 43, ICSDF=P, ...

Data        .
Base        .
Changes     .
            P R
            E X
```

If the interface device is the CRT, the following message and prompt character will be provided on the CRT:

```
ENTER DBASE DIRECTIVES(RE, SA, PR, MO, EX)
[
```

The operator will then enter the desired directive mnemonic immediately following (i.e., starting in column 2 and on the same line), the directive prompt character ([) and press the carriage return key. Each time a directive is completed, DBASE returns the directive prompt character until the operator signifies end of DBASE processing by entering the EX directive.

If the MO (modify) directive is specified, DBASE will return a data prompt character (<). The operator will enter the desired parameter changes immediately following the data prompt character and in the same manner as for card input (i.e., free-field format, parameter symbols, separated by commas, and a maximum of 70 characters per line). Each time a data line is transmitted, DBASE will return the data prompt character on the next line. This continues until the operator signifies the completion of all data base parameter modifications by pressing the carriage return key without entering any changes behind the data prompt character. To illustrate the interaction between DBASE and the operator when the CRT is the interface device, the example given above for card input would appear on the CRT as follows:

```
ENTER DBASE DIRECTIVES(RE, SA, PR, MO, EX)
[MO
<IANNOT=43, ICSDF=P, ...
.
.
.
<
[PR
[EX
```

If the PRINT directive is entered and the line printer is unavailable, the request will be suppressed and the following message output on the OC:

LP DEVICE NOT AVAILABLE

This action is taken whether the directive is entered by card or CRT.

DBASE enters all changes to the in-core data base into the Processing Log file. All static data base parameters are entered each time a RESTORE directive is processed. All individually modified parameters are entered each time a MODIFY directive is processed.

b. WOCPROC

All work order data is entered into EDIPS using module WOCPROC. WOCPROC must be activated during the set-up phase for each processing period. It may be activated any number of times during the processing period to enter additional work orders. A maximum of 100 work orders may be entered during set-up and are placed in file WOCFILE. An additional 100 may be entered in any desired increments during the processing period and are placed in file TEMPWOC. Each time the work orders in WOCFILE are completed, those in TEMPWOC are automatically transferred to WOCFILE for processing. TEMPWOC is then free, and up to an additional 100 work order cards may then be entered. This process continues until both files are empty.

The operator enters the command ACTIVATE WOCPROC on the OC. For WOCPROC to execute, either the CRT or card reader (CR) must be available. Upon activation, WOCPROC checks the availability of each of these devices and takes one of the following actions:

1. If neither the CRT nor the CR is available, the operator will be notified on the OC that WOCPROC must abort due to no input device being available. WOCPROC will then exit without attempting to enter the new work order data.
2. If only one of the devices is available, the operator will be notified on the OC which device (CR or CRT) must be used.

3. If both the devices are available, WOCPROC will query the operator and allow him to specify via the OC which device is to be used.

Assuming that either Condition 2 or 3 occurs, WOCPROC can be executed and work order data entered.

If the CRT is available, independent of whether the CRT or CR is the input device, the following query will be output to the OC:

WORK ORDER REVIEW ON CRT? (Y, N)

If the response is Y (YES), each work order will be displayed on the CRT for operator review and modification. If N (NO), the display will be provided only if an error is detected.

If the line printer is available, the following query will also be output to the OC:

WORK ORDER PRINTOUT DESIRED? (Y, N)

If the response is Y, a hardcopy of each work order entered, whether entered by cards or through the CRT, will be provided on the line printer.

If the CR is the input device, the input deck is organized as follows:

Card 1, Work Order 1
.
.
.
Card 1, Word Order N
(Optionally) Cards 2 or 3 of Work Order N
EOF Card (2,3,4,5 Multi-Punch in Column 1)

If a review of the work orders has been requested, the display shown in Figure 4-2 is presented on the CRT. The display is presented sequentially as each work order is processed. The parameters denoted by numbers 1 through 23 represent the aggregate data items specifiable from all three work order cards. Refer to Section V for additional information on Work Order Cards.

For each word order, values for parameters which are input as well as those which are implied (i.e., default values taken from the data base), are displayed. Any superfluous entries (i.e., extra parameters input that do not generate any errors) will appear on the display but not be used or affect the processing. For example, if the input tape is an HDT and the CCT density is input, the density will be taken as a superfluous entry. Likewise, if an edge enhancement kernel value is specified but edge enhancement is not specified in the process codes, the kernel value would be a superfluous entry.

```
NUMBER OF ERRORS= 0
    1. SI= X                          2. STORE= X X X X X X          3. TAPE ID= X X X X X X
    4. TAPE TYPE= X                   5. SENSOR= X                   6. TYPE HDT= X
    7. DENSITY= X                     8. PROD CODE= X X X            9. BIN= X X X X
    10. TIME= X X X X X X X X X X     11. NUM SCENES= X X            12. SCENE= X X X X X X X X X X X X X
    13. BANDS= X X X X X              14. REV/TRUE= X                15. TABLE= X
    16. SPACE= X                      17. CS UNITS= X                18. KERNEL= X X X X
    19. PROC CODE= X X  X X  X X  X X  X X  X X  X X  X X  X X  X X  X X  X X  X X
    20. ORDER/UNIT= XXXXXXXXXXXXXX  XXXXXXXXXXXXXX  XXXXXXXXXXXXXX
    21. MIN CS= XXXX XXXX XXXX XXXX XXXX
    22. MAX CS= XXXX XXXX XXXX XXXX XXXX
    23. HR BIAS= XXX XXX XXX XXX XXX
ENTER WOCPROC DIRECTIVE (MO, AC, RJ)
[
```

DISPLAY

DISPLAY KEY

DISPLAY PARAMETERS		WORK ORDER CARD PARAMETERS		
NUMBER	DESCRIPTOR	DEFINITION	COLUMNS	CARD NUMBER
1	SI	SPECIAL INSTRUCTIONS	1	1, 2, 3
2	STORE	STORAGE LOCATIONS	4-9	1
3	TAPE ID	TAPE ID	10-15	1
4	TAPE TYPE	TAPE TYPE	16	1
5	SENSOR	SENSOR AND MISSION	17	1
6	TYPE HDT	TYPE	18	1
7	DENSITY	CCT DENSITY	19	1
8	PROD CODE	PRODUCT CODE	20-22	1
9	BIN	BIN NUMBER	33-36	1
10	TIME	IRIG TIME CODE	37-46	1
11	NUM SCENES	NUMBER OF SCENES	47-48	1
12	SCENE	SCENE ID	49-61	1
13	BANDS	BAND SELECT	62-66	1
14	REV/TRUE	REVERTED/TRUE	64	2
15	TABLE	TABLE SELECTION	65	2
16	SPACE	SPACE FORWARD	66	2
17	CS UNITS	CONTRAST STRETCH UNITS	4	3
18	KERNEL	EDGE ENHANCEMENT KERNEL	60-63	3
19	PROC CODES	PROCESS CODES	23, 32, 4-21	1, 2
20	ORDER/UNIT	ORDER NUMBER AND UNIT	67-80	1, 2, 3
21	MIN CS	MINIMUM HISTOGRAM CUTOFF	5-44	3
22	MAX CS	MAXIMUN HISTOGRAM CUTOFF	5-44	3
23	HR BIAS	HISTOGRAM SHIFT	45-59	3

Figure 4-2. Work Order Display Format

The work order review process is controlled through a set of WOCPROC directives defined below. The STOP directive is used only when the CRT is the input device.

DIRECTIVE	MNEMONIC	APPLICABILITY	DEFINITION
STOP	ST	CRT Input	Terminates Work Order Input Process
MODIFY	MO	REVIEW	Changes to Work Order Data Follow
ACCEPT	AC	REVIEW	Accept Work Order Data As Is
REJECT	RJ	REVIEW	Abort Work Order

If the operator wishes to accept the work as is or reject the work order, directive AC or RJ is entered immediately following (i.e., starting in column 2 and on the same line) as the directive prompt character ([) and transmitted. WOCPROC will take appropriate action and proceed to the next work order. If the operator desires to change one or more of the parameter values, directive MO is entered immediately following the directive prompt character and transmitted. WOCPROC will return a data prompt character (<) to notify the operator to enter parameter value changes. The parameter changes are entered subject to the following rules:

1. Each parameter to be changed is entered using the parameter number from the display and only one parameter transmitted per line.

2. Parameters having multiple values (e.g., ORDER/UNIT, PROC CODES, etc.) are specified by parameter number and index, and the multiple values may be input on the same line using commas between values.

3. The parameter number is entered immediately following the data prompt character and the values entered immediately following the equal sign with no blanks inserted unless intentionally entered in an alphanumeric parameter.

4. All parameters are assumed to have the same field width as defined for the work order card.

5. All values are right-justified; a semi-colon is used as the delimiter for alphanumeric parameters when BLANK characters are inserted at the end (i.e., right-hand side) of either a single valued parameter or the last value of a multi-valued parameter.

6. The completion of the modification process is signified by pressing the carriage return key without entering any data behind the data prompt character.

To illustrate the modification procedure, assume that it is desired to turn bands 4, 5, and 6 on and bands 7 and 8, off; to change the edge enhancement kernel to a 5 by 5; to change the second and third process codes to values 51 and 52, respectively; to change the fifth process code to a value of 94; and to make the unit portion (3 characters) of the ORDER/UNIT parameter be blank. To accomplish this, the operator would respond as follows:

```
[MO
<13=111bb;
<18=0505
<19(2)=51,52
<19(5)=94
<20(1)=A1234123456bbb,A1234123456bbb,A1234123456bbb;
<
```

In reality, only one of the ORDER/UNIT numbers is required to be entered but this illustrates the procedure if all three are entered and BLANK characters used for the UNIT portion. If no BLANK characters were used at the end of either the BANDS or ORDER/UNIT parameters, a semi-colon would not be required since the entire field width would be specified.

WOCPROC will display the resulting work order each time a modification is made until the operator either accepts or rejects the work order. This would mean that the operator must delete, add, or change values. For example, carrying the case to an extreme, assume that it is desired to change a work order from a film output to a CCT product. It would be necessary to change the Product Code and perhaps, add values to the Processing Codes and it would be desirable to also remove (i.e., enter the appropriate number of BLANK characters) each of the existing film parameters (e.g., REV/TRUE, TABLE, etc.), or these parameters will remain on the display as superfluous entries.

If the CRT is the input device, the following command and data prompt character will appear on the CRT:

```
ENTER WORK ORDER DATA
<
```

The operator will enter the desired parameters subject to the same rules presented earlier for the modification procedure. Each time a word order is entered (signified by returning the data prompt character with no parameters following the prompt character), WOCPROC responds with the ENTER WORK ORDER DATA command to allow the next work order to be entered. To terminate the process, the operator responds with the STOP

directive following the data prompt character. A typical sequence of entering work order data via the CRT is shown below:

```
ENTER WORK ORDER DATA
<2=820315
<8=97
.
.
.
<
ENTER WORK ORDER DATA
<1=X
<2=809727
.
.
.
<
.
.
.
ENTER WORK ORDER DATA
<3=721417
<5=3
.
.
.
<ST
```

If the work order review has been requested, the review display shown in Figure 4-2 and discussed previously will be presented prior to the next ENTER WORK ORDER DATA command. The operator has the full range of responses available just as for card input.

At this point, certain assumptions/restrictions should be pointed out in regard to the relationship between Product Code, Contrast Stretch (CS) Units, and Min/Max CS cut-off Values. The use and relationship between these parameters (in fact, all parameters) is unambiguous when the work order data is input via cards and not modified from the CRT. However, carried to the extreme, potential pitfalls and inconsistencies exist when the modification capability is superimposed on the rules governing the interpretation of data input/not input, and the use of default values from the data base. The assumptions/restrictions adopted by WOCPROC in this area are as follows:

1. If the resulting CS unit is G (grey level), the "spike" algorithm has no meaning. The resulting Min/Max CS cut-off values (checked to be between 0 and 255) are used in the "radiance level cut-off" algorithm independent of whether the work order is pipeline or special-order.

2. If the resulting CS unit is P (percent) and the work order is pipeline (Product Code=97), the Min/Max Spike Values from the data base and the resulting Min/Max CS values will be used in the spike algorithm.

3. If the resulting CS unit is P and the work order is special-order, the Min/Max Spike Values and Min/Max CS Values from the data base will be used in the spike algorithm provided the Min/Max CS Values are not input (i.e., not entered from card 3 or entered from CRT), or subsequently modified. If the Min/Max CS Values are input or modified, the resulting Min/Max CS Values will be used in the "straight percent cut-off" algorithm.

4. If a band/subscene is selected for processing through parameter BANDS, and any required contrast stretch and/or haze removal values are not specified, the data base values will be initially selected for that image independent of the specification method (i.e., input, data base default, modification) of any other image selected. The only condition is that the CS Units specified for this work order and the value in the data base must agree. If not, an error condition will be generated.

5. The resulting Product Code, Process Codes, and the images selected for processing (parameter BANDS) specify the processing performed and what is processed, not the presence of values in the contrast stretch, haze removal, edge enhancement parameters.

In all of the discussion above, the term "resulting" denotes the existing value of a parameter based on the total combination of operations (i.e., initial input, default selection modifications) performed to a given point. Naturally, if accepted, the resulting values following the last operation represents the work order processed.

To assist in monitoring the EDIPS processing, WOCPROC will display one of the following messages on the OC, when appropriate:

WOCFILE HAS DATA, MAY ACTIVATE SCHEDULER

or

TEMPWOC IS EMPTY, MAY ENTER MORE WOCS

The first message is output when the initial set of work orders are completed and alerts the operator that module SCHED may be activated at any time to begin the processing step. The second message is output when the work orders in the TEMPWOC file have been transferred to the WOCFILE. This will advise the operator that TEMPWOC is free and up to an additional 100 work orders may be entered if desired.

c. WOCPROC Error Processing

In addition to the insufficient devices condition discussed earlier, error conditions detectable by WOCPROC fall into the following categories:

1. Card missing/out-of-order or card number not 1,2,3

2. Incorrect/incomplete word order data

3. Invalid directive

4. Invalid format

5. Maximum number of work orders exceeded

Obviously, error category 1 is pertinent only to card input. If this type error occurs, WOCPROC will abort after displaying one of the following messages on the OC as appropriate:

CARD NNN OUT OF ORDER, WOCPROC ABORT

or

CARD NNN BAD, WOCPROC ABORT

The number NNN (e.g., 217) identifies that the error was detected on the Nth (e.g., 217th) card in the card deck. None of the work orders in this submittal will be entered into the system for processing. The operator must correct the error, activate WOCPROC, and resubmit the entire card deck.

Error category 2 is appropriate to either card or CRT input as well as modified or unmodified data. In this category, WOCPROC performs four distinct groups of tests, each group consisting of the specific tests indicated below:

ERROR GROUP I. Order/Unit

- Card 1 must contain an Order/Unit identifier
- At least one Order/Unit identifier, position 20(1), must be entered from the CRT
- Multiple Order/Unit identifiers must match

ERROR GROUP II. Primary Required Data

- IRIG time must be numeric and all 10 fields specified (HDT input only)
- Scene ID must be non-blank
- Tape ID must be non-blank

- Tape Type must be H or C
- Type must be A or P if Tape Type is H
- Density must be 1 or 2 if Tape Type is C
- Sensor must be 1, 2, 3, N, or R

ERROR GROUP III. Secondary Required Data

- Images (bands/subscenes) selected not compatible with indicated sensor and mission; BAND SELECT must be filled in on work order for special orders
- No images selected for special orders (for pipeline processing data base values will be used if nothing selected)
- Product Code must be 03, 13, 83, 84, or 97
- Process Codes must be 51, 52, 53, 72, 73, 91, 92, 93, or 94
- Same Process Code appears more than once
- Process Codes 51 and 52 used but not entered as a "pair" (i.e., contiguous entries)
- Incompatible or incomplete combinations of Product Code, Process Code, and input type.

ERROR GROUP IV. Appropriate Parameter Values Undefined/Out of Range

- Space code not S or blank
- Rev/True not R, T or blank
- HRFR Table not 1, 2, 3, 4, or 9
- Contrast Stretch Units not P, G, or blank
- Edge Enhancement Kernel cannot exceed 9 by 9 and each value must be odd
- Histogram Shift not between 0 and 255
- Minimum/Maximum Contrast Stretch cut-off values must be between 0 and 255 if Contrast Stretch Units is G; must be between 0 and 9999 if P
- Number of scenes to process not specified for pipeline

- Number of scenes to process greater than 1 for special orders
- Default Min/Max CS cut-off values and units conflict with specified CS Units

Table 4-3 presents the required and legitimate combinations of Product Code/Process Codes corresponding to Test III-7 from above.

The four error groups are checked sequentially by WOCPROC and a check for errors is made following the completion of the tests comprising each group. If one or more errors occur in that group, the processing of the work order is halted until the errors can be corrected or the work order is aborted. This procedure is necessitated by the fact that it is fruitless to continue if the Order/Limit is in error, Group III checks are dependent on the sensor, tape type, etc., from Group II, and so forth. If errors occur within any group, and the CRT is available, an error display is presented

Table 4-3. Product Code/Process Codes/Input Type Usage

Product Code	Input Type	Required/Allowable Process Codes
97	HDT-P	Only 51 and/or 52 can be specified; if none are specified, the haze removal/contrast stretch selection is automatically taken from the data base
03 or 13	CCT (Corrected data only)	None
03 or 13	HDT-P	51, 52, 53, and 72 are allowed
83 or 84	HDT-PM	51, 52, 53, 72, and either 93 or 94 are allowed; 73 and either 91 or 92 are required
83 or 84	HDT-PR	51, 52, 53, 72, and either 93 or 94 are allowed; 73 is required (91 or 92 will produce an error)
83 or 84	HDT-AM	73 and either 91 or 92 required; no others allowed
83 or 84	HDT-AR	73 required; no others allowed

on the CRT. These errors must be corrected before the next test group is checked. The error display is identical to the review display shown in Figure 4-2, except for the following:

- The first line will provide the total number of errors detected
- The blank space preceding each parameter name will contain a blinking asterisk (*) if this parameter is in error
- The last two lines will be displayed as

  ENTER WOCPROC DIRECTIVE (MO, RJ)
  [

  since the ACCEPT directive is inappropriate.

The operator error response procedure is identical to the review procedure. Following a modification, WOCPROC returns to Error Group I and sequentially performs the tests. If a modification does not remove all errors or introduces new ones, the resulting error display will be presented until all errors are resolved or the work order rejected by the operator.

If the work order review has been requested, the standard review display is presented after all errors have been resolved. If the review has not been requested, the resulting error-free work order is accepted.

If any Category 2 errors occur and the CRT is not available, this work order only is automatically rejected by WOCPROC with an appropriate message to the OC. The errors must be corrected and the work order resubmitted on a subsequent activation of WOCPROC.

Error Category 3 is appropriate only to entering or modifying data via the CRT. If an invalid directive is entered, WOCPROC will reject the directive and display the following message on the CRT:

INVALID WOCPROC DIRECTIVE

WOCPROC will then display the appropriate ENTER WOCPROC DIRECTIVE message on the CRT.

Category 4 errors can occur only when modifying or entering work order parameter values from the CRT. If any of the rules presented earlier for entering work order data via the CRT are violated (i.e., parameter value must be between 1 and 23, one parameter per line, etc.), WOCPROC will reject the data and display the following on the CRT:

INVALID FORMAT, LAST INPUT DROPPED
<

The operator should respond by entering the correct data in the correct format immediately following the data prompt character.

A Category 5 error can occur during any activation of WOCPROC and is independent of input device. If an attempt is made to enter more than a total of 100 work orders into either the WOCFILE or TEMPWOC files, WOCPROC will not accept the excess work orders. These excess work orders must be resubmitted, at any subsequent time if WOCFILE is full, and subsequent to the TEMPWOC empty message if TEMPWOC is full. In any event, WOCPROC displays the following message on the OC:

DDDDDDD FULL, WOCPROC ABORTED

in which DDDDDDD is WOCFILE or TEMPWOC, as appropriate. WOCPROC will then immediately display the following on the OC:

ABORT, LAST WOC WAS XXXXXXXXXXXXXX

in which the X...X identifies the Order/Unit number of the last work order accepted and aids in determining which work order must be resubmitted. Naturally, this identifier will be blank if the TEMPWOC file is already full when WOCPROC is activated and, consequently, no work orders could be accepted.

The last message presented above is actually displayed on the OC any time WOCPROC aborts. The abort can be WOCPROC-generated (i.e., occurrence of one of the error conditions described above such as card out of order, etc.), RTM-generated, or from module STOPFLOW if WOCPROC is processing when the operator activates STOPFLOW.

d. FILMCH

Module FILMCH provides the capability for the operator to change the film roll/frame number and/or the TIFT. The operator enters the command ACTIVATE FILMCH on the Operator's Console. However, its use is restricted to the set-up phase of a processing period. During processing, a change to the film roll/frame number and/or TIFT can be made only in conjunction with the HRFR low film warning.

4-5. PROCESSING

The processing step of each processing period is initiated by the operator entering the command ACTIVATE SCHED from the Operator's Console keyboard. During the resulting processing a number of status, prompting, query, and error messages are provided to the Operator's Console (OC). Some of the messages are automatically provided; others must be specifically requested by the operator. Naturally, the occurrence and sequence of the automatically-provided messages

and the need for the operator-requested messages are highly dependent on the work orders present, device condition and availability, etc.

a. Normal Processing

During normal processing, messages automatically provided to the operator (at the OC) relate to four areas:

1. Tape mount/dismount

2. HRFR film change

3. LOGFILE overflow alert

4. Processing completion

A tape mount/dismount message is provided for both HDT and CCT applications. When appropriate, the message identifies the unit and/or tape involved. The HRFR film change involves a series of messages and queries which require operator response and action. EDIPS creates a processing log (LOGFILE) which contains a time-ordered account of the processing performed, errors encountered, recovery attempts, and device usage. If the LOGFILE is in danger of overflowing, Module LOGGEN will alert the operator to purge the file or lose some of the messages. When a processing period is completed (i.e., all work orders have been processed), the message EDIPS IDLE is output to the OC. EDIPS then idles awaiting the next operator action which must be to either initiate the next processing period (i.e., DBASE, WOCPROC, FILMCH, SCHED), or terminate.

b. Error Processing

During the EDIPS processing, a variety of error conditions are possible, arising from erroneous data and/or malfunctions of the various peripheral devices. Table 4-4 summarizes the error condition(s), applicable modules, message content, and recovery procedures.

The Operator's Console (OC) is the interface device where operator response is indicated, or when a work order is aborted. Normally, aborts of individual bands/subscenes in pipeline processing are placed only in the processing log, and not displayed on the OC.

c. LOG

As indicated earlier, EDIPS produces a processing log with information on processing performed, errors encountered, recovery attempts, and device usage. In addition, pertinent information is gathered which summarizes the processing activity for the present run. Selected portions of the LOGFILE as well as summary data may be displayed on the CRT.

Table 4-4. EDIPS Error Conditions and Recovery Procedures

Error Condition	Module(s)	Message Content	Output To OC	Output To Processing Log	Action Taken	Operator Response Required
IRIG-A Time or Greater Not on Tape	INSRCH	IRIG-A Time from WO, Tape ID, WO number	X	X	Abort WO	
Incorrect Scene ID	INHDT	Scene ID from WO versus First Scene ID checked on the Tape	X	X	Try up to NSRCH (Data Base Parameter) Images for a match. If no match found, abort WO.	
HDTR/SCI/HCS • Parity Error	INHDT	Count of Detectable parity errors per MSS band or RBV subscene	X	X	If Parity errors exceed MXPARY (Data base parameter), output message to OC and retry band or subscene up to NTRYPR (data base parameter) times. If unable to recover, abort band or subscene if pipeline or WO if special	
HDTR/SCI/HCS • Missing Data • Synch Error	INHDT	Subscene ID, band or subscene number	X	X	Perform up to NTRYMD (data base parameter) retries. If unable to recover, abort band or subscene if pipeline or WO if special orders.	
HDT Format Error	INHDT	WO number, scene ID and frame type	X	X	Abort WO	
HDTR/SCI/HCS • Fatal Error	INHDT	Indicate nonrecoverable device error. Include WO number, Scene ID, band/subscene number.	X	X	Abort WO and make device unavailable	
CCT (Read) • Unsuccessful Retry	INCCT	Indicate type error and unit number. Include WO number, Scene ID, and band/subscene number.	X	X	Abort WO	

Table 4-4. EDIPS Error Conditions and Recovery Procedures (Continued)

Error Condition	Module(s)	Message Content	Output To OC	Output To Processing Log	Action Taken	Operator Response Required
CCT (Read) • Missing Line(s) • Invalid Format	INCCT	Indicate type error. Include WO number, Scene ID, and band/ subscene number, as appropriate.	X	X	Abort WO	
CCT (Write) • Unsuccessful Retry	PGDIGI	Indicate type error and unit number. Include WO number, Scene ID, and band/ subscene number.	X	X	Allow operator to do one of the following: 1. Abort WO 2. Mount new tape and start writing at beginning of tape.	X
CCT Fatal Error • Data Late • Time Out	INCCT PGDIGI	1. Indicate type error and unit number. Include WO number, Scene ID, and band/ subscene number. 2. Prompt operator to use system command OFFLINE to advise RTM that device is unavailable.	X	X	Abort WO and make device unavailable.	X
Disk (System/Image) • Data Error	All IPS modules except APHFE, IPRAC, and PGTIFT	Provide MSS band or RBV subscene; WO number and disk ID	X	X	Abort band/ subscene if pipeline or WO for special orders	
Disk Fatal Errors • Seek Error • Data Late • Time Out	All IPS modules except APHFE, IPRAC, and PGTIFT	Indicate type of non-recoverable device error. Include WO number, Scene ID, MSS band or RBV subscene, and Disk ID	X	X	Abort scene/ subscene for pipeline or WO for special orders. Make device unavailable	
AP-120B-Fatal Errors	IPHFE	Indicate nonrecoverable device error. Include WO number, Scene ID, and band or subscene number	X	X	Abort WO and make device unavailable	
HRFR • Data Late (buffer underflow) • Time Out • Byte Count Error	PGFILM	Indicate type error. Include WO number, Scene ID, and MSS band or RBV subscene	X	X	Start transfer of MSS band or RBV subscene over. If error recurs, abort band/subscene if pipeline or WO if special order	

Table 4-4. EDIPS Error Conditions and Recovery Procedures (Continued)

Error Condition	Module(s)	Message Content	Output To: OC	Output To: Processing Log	Action Taken	Operator Response Required
HRFR • Master Fault • Frame No. >999	PGFILM	Indicate type of non-recoverable device error. Include WO number, Scene ID and MSS band or RBV subscene	X	X	Place HRFR in STANDBY. Query operator as to continue or abort HRFR. If continue, re-start at band/ subscene for master fault or set frame number to zero. If abort, make HRFR unavail-able for fur-ther process-ing and abort WO.	X
TIFT • Unsuccessful Retry	PGFILM PGDIGI	Indicate type of error. Include WO number, scene ID, band or subscene number, and TIFT record number.		X	Continue	
TIFT • Fatal Error • EOM	PGFILM PGDIGI	Indicate type of error. Include WO number, Scene ID, band or subscene number, and total number of records on TIFT.	X	X	Abort WO and make device unavailable.	
Operator determined hardware failure					Operator activates module DEVSET	X
RTM	Any	Module name and RTM abort	X	X	Processing terminated and any remaining work orders discarded.	

A hardcopy print of the summary data, the entire LOGFILE, or only selected portions may also be obtained. The hardcopy print, especially if all or a major portion of it is desired, should be obtained only during the termination phase (see Section 4-6), or during an EDIPS idle cycle. The CRT display and hardcopy print are provided using module LOG.

It cannot be emphasized strongly enough that the use of LOG during regular EDIPS processing should be kept to a minimum. Printout of a large portion of the processing log or excessive and constant displaying of LOGFILE information to the interactive devices will tie up the computer, line printer, operator's console, and CRT to the detriment of regular processing.

d. DEVSET

This module provides the capability for the operator to change the availability of the peripheral devices involved in the EDIPS operation, except for the Operator's Console (OC), and TIFT (Magnetic Tape Unit). Using DEVSET, devices presently in use can be made unavailable, or devices presently down can be made available. Although not controlled by DEVSET, subsequent EDIPS processing will reflect the new device availability. That is, the processing limitations shown in Table 4-1 will be observed on all on-going and remaining work orders, whether the limitations were loosened or tightened by the changes.

e. STOPFLOW

This module provides the capability to gracefully terminate the processing prior to normal completion of the processing period. The only required action is for the operator to enter ACTIVATE STOPFLOW on the OC. STOPFLOW will set the necessary control parameters such that work orders in progress will be terminated, and any remaining work orders will be discarded (i.e., not processed and permanently removed from the work order queue). Just as for normal completion, the message EDIPS IDLE will be output to the OC and the system idles awaiting the next operator action (initiate next processing period or terminate).

4-6. TERMINATION

Upon completion of the last desired processing period, Module WRAPUP must be activated. The last processing period can be arrived at because the computer is being powered down at the end of the day, or for maintenance, or for any other reason affecting the normal processing functions. In any event, Module WRAPUP must be executed to terminate the EDIPS modules residing in core as well as to save certain data required for the next EDIPS run. The operator enters the command ACTIVATE WRAPUP on the OC.

Although not requiring a direct operator interface, WRAPUP also performs two functions that affect the other interfaces:

- Stores the latest values for all dynamic parameters, including roll and frame number in the data base.
- Writes EOF records on the TIFT and rewinds the tape in the event this tape is not to be used during the next start-up phase.

Module WRAPUP also provides the opportunity to obtain any desired LOGFILE data as well as SEMS print.

4-7. DIAGNOSTICS

Three diagnostic programs are available to be run off-hours or, at least, on a non-interference basis with the EDIPS production system. These programs are the following:

- HDTRONL
- HRFRONL
- DSKVFY

The first two programs allow the user to exercise the HDTR/SCI/HCS and HRFR/TCS, respectively, to obtain the operating status of each device.

DSKVFY allows the user to ascertain which 80 MB disk cylinders cannot be used. The unusable cylinders are stored on each disk as the SCT (Sealed Cylinder Table) file and read into core by module START. Only the cylinders reserved for imagery are checked. During a run, all cylinders identified as unusable are bypassed.

Whenever the operator has reason to question the integrity of a disk or a new disk is placed in the system, DSKVFY should be executed. If a rejected disk is not being replaced, the operator should make the disk unavailable during the EDIPS start-up phase.