SECTION V

USER APPLICATION INFORMATION

This section discusses user control and/or modification of the EDIPS processing functions, describes the HDT, CCT, and film product formats, and discusses the image enhancement algorithms utilized.

5-1. USER CONTROL/MODIFICATION OF EDIPS PROCESSING FUNCTIONS

Control of the EDIPS processing is provided through Work Order Cards (WOCs), data parameters, and SEL RTM operating-system features. The latter are available with all SEL 32/55 computer facilities using RTM, and thus will not be discussed further in this section. The WOCs are uniquely constructed to the specifications of the EDIPS user, and their use and characteristics are discussed in detail in this section. The data base parameters are not directly accessible to the user (except by default conditions), but allow operator control of various processing parameters as described in the next paragraph.

5-2. MODULE 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. They include such parameters as the intensity level for film annotation, the number of film gap lines used between MSS bands or RBV subscenes, the number of lines/pixels in the edge enhancement kernel, contrast stretch cutoff values, the haze removal bias, and histogram scaling. (Refer to Table 4-2 for a complete listing of all data base static parameters and their ranges.)

The user may modify these static parameters in the EDIPS data base using either the card reader (and suitably prepared card decks) or the CRT; Module DBASE is used with either device. A set of data base parameter values is always stored in a permanent file on disk. During start-up this set of values is automatically loaded into core and becomes the "in-core" data base. These static parameters can only be changed by the user and are cumulative in nature. Refer to Section IV for additional details on the use of Module DBASE.

5-3. WORK ORDER CARDS (WOCs)

The EDIPS user also controls EDIPS processing functions through the use of Work Order Cards (WOCs). These are punched cards which may be prepared manually (key punched), or output by scheduling programs in the EDC B6700. In any event, the user can specify desired parameters for image

enhancement functions (e.g., Haze Removal, Contrast Stretch, and Edge Enhancement) and film generation, CCT format, and other process or product functions. Three distinct types of WOCs are available to control processing through EDIPS.

a. Work Order Card One (Figure 5-1)

Card One is required for all orders processed through EDIPS specifying tape input, processes to be performed, and destination of output products. For pipeline processing, a single Card One is required for each pass (subswath) to be processed from the HDT. For special orders, a Card One followed by any necessary Card Two or Card Three is required for each HDT scene to be processed.

b. Work Order Card Two (Figure 5-2)

Card Two is used for special orders where more than five process codes are required, and/or where film parameters are to be selected that are different from normal (default) values, or those implied by the product code.

c. Work Order Card Three (Figure 5-3)

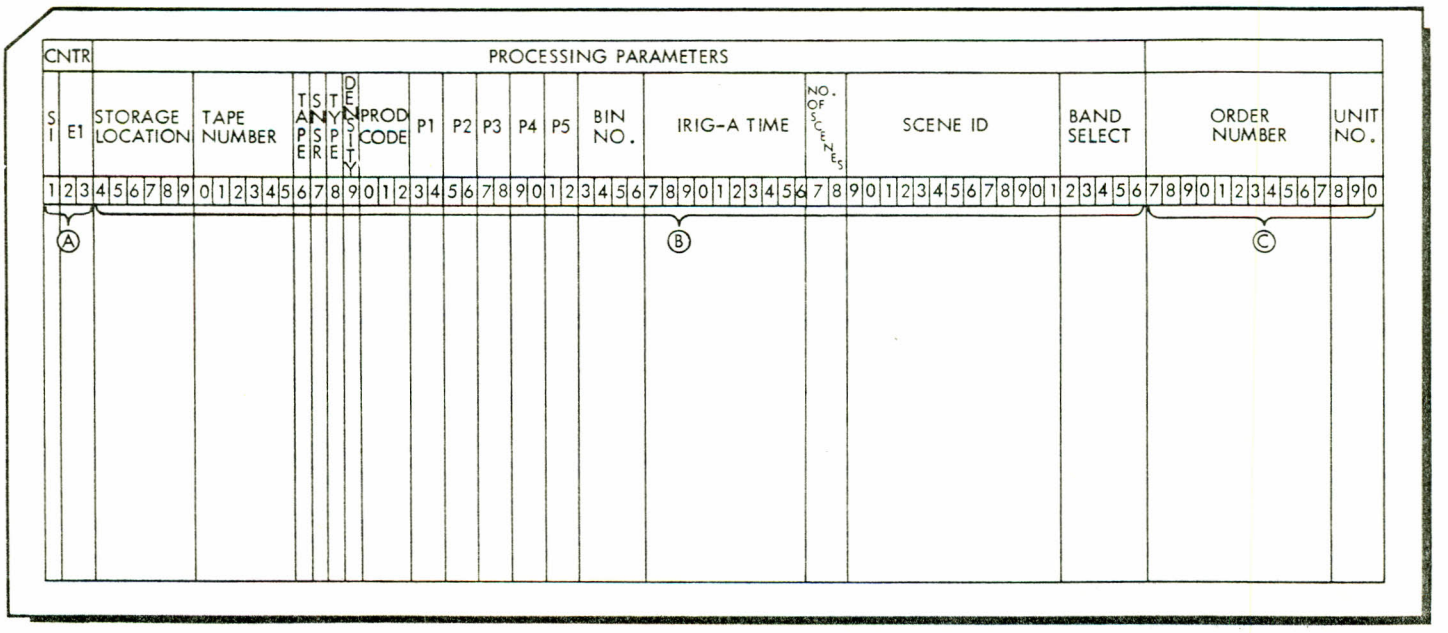
Card Three is used only for special orders where user selections are required for manual histogram cutoff (Contrast Stretch), histogram shifts (Haze Removal), or kernel size (Edge Enhancement).

Work order data and parameter values may be reviewed and modified during the set-up phase using the CR and/or the CRT. Under control of WOCPROC and the user, work orders are displayed sequentially and values of parameters input by the user as well as those implied (i.e., default values taken from the data base) are shown. The user can change, add, or delete one or more of the displayed parameter values on the cards. Refer to Section IV for additional information in WOCs and user procedures.

d. Product Code/Process Code Usage Constraints

The processing and product mix requirements for EDIPS imply certain relations and restrictions between the Product Code and the Process Codes specified on the WOCs. Process Codes are those items listed under PS in Table I of Figure 5-1. The usage of these parameters is explicitly defined by the following rules/restraints:

1. Only Processing Codes 51 and/or 52 can be specified for a Product Code of 97 (pipeline processing). If none are specified, the haze removal/contrast stretch selection is automatically taken from the data base specified value.



DATA CONTENT OF CARD ONE

GROUP A : CONTROL SECTION (Cols 1-3)

Column	Item/Description	
1	Special Instructions:	Indicates whether special instructions accompany this order. A non-blank code causes message to be printed to EDIPS operator.
2	Process Indicator:	Provides program identification of card as EDIPS.
3	Card Number:	Indicates card number is 1, 2, or 3

GROUP B : PROCESSING PARAMETERS (Cols 4-66)

4-9	Storage Location:	Indicates shelf location of input tape. Can be ignored by EDIPS except as it appears on printed outputs
10-15	Tape Number:	Internal tape number of input tape. Matched and verified by EDIPS with characters 7-12 of tape directory record
16	Tape Type:	H = HDT, C = CCT
17	Sensor and Mission:	1 = LANDSAT 1 (4 Band) 2 = LANDSAT 2 (4 Band) 3 = LANDSAT C (5 Band) N = Nighttime (1 Band) R = RBV
18	Data Type:	P = Corrected (HDT-P), A = Raw (HDT-A)
19	CCT Density:	1 = 800 BPI, 2 = 1600 BPI
20-22	Product Code:	Defines output product as specified by Table I
23-32	Process Code:	Defines processes to be applied by EDIPS as specified by Table I
33-36	Bin Number:	Shipping location for the customer product. For manual interpretation; not used in EDIPS
37-46	IRIG Time Code:	IRIG code of the input HDT where slowdown (i.e., going from search to read speed) for the scene or subscene should begin
47-48	Number of Scenes:	Number of scenes in the pass (subswath) to be processed by this WOC. This field is deployed in pipeline mode only

Figure 5-1. Work Order Card One (Sheet 1 of 2)

GROUP B : PROCESSING PARAMETERS (CONT)

Column	Item/Description	
49-61	Scene ID:	For pipeline, this is the scene ID for the first scene of a pass (subswath) to be processed on the input HDT. For special orders, this represents the ID of the specific scene to be processed. The rightmost eleven characters of this field (Cols 51-61) are to be matched with the scene ID found in the header section (characters 2 thru 12) of each band or subscene
62-66	Band Select:	Indicates those MSS Bands (or RBV Subscenes) to be processed for the scenes selected in a special order:

Sensor	Column	Entry	Select
MSS	62	4	Band 4
	63	5	Band 5
	64	6	Band 6
	65	7	Band 7
	66	8	Band 8
RBV	62	A	Subscene A
	63	B	Subscene B
	64	C	Subscene C
	65	D	Subscene D
	66	(Not Used)	

GROUP C : ORDER CONTROL (Cols 67-80)

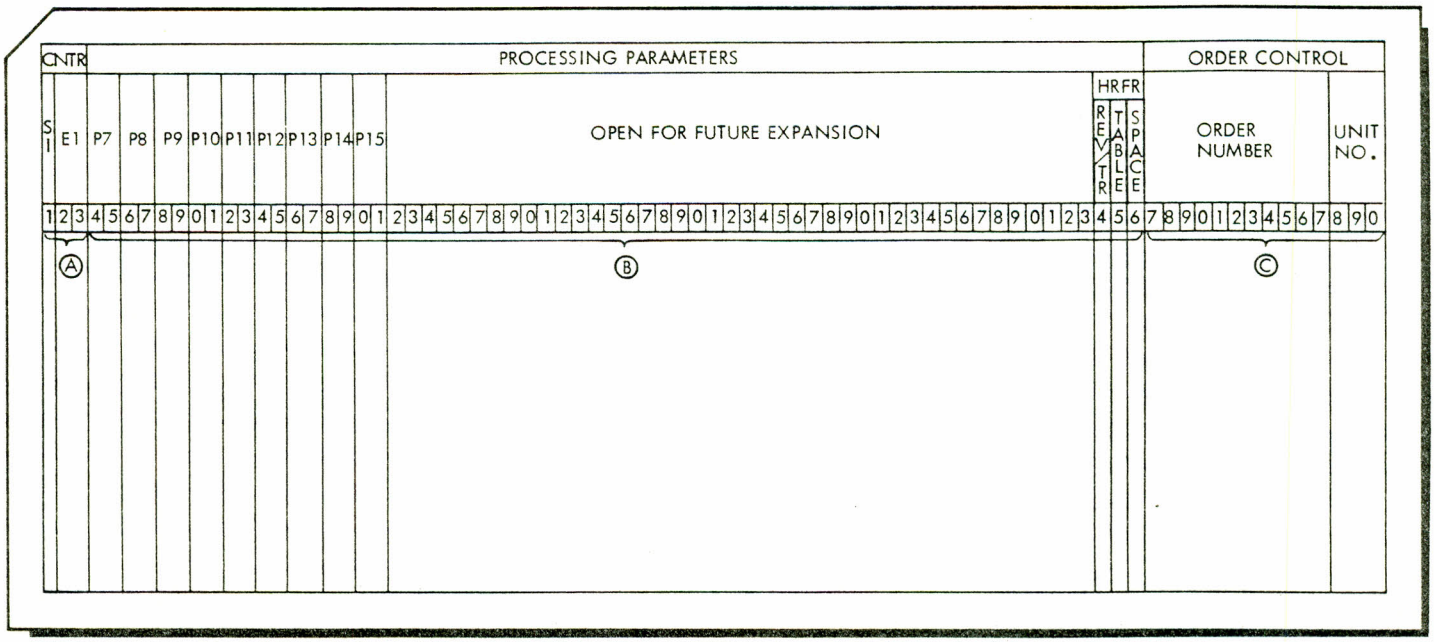
67-80	Order Number & Unit:	Used by EDC B6700 to reference this pipeline or special order. EDIPS must use this number for multicard orders to identify all cards pertaining to the same work order.

TABLE I. PRODUCT/PROCESS CODE

Product Code	Product Description	Product Source	Process Code	Option Selections
03	Film, B & W Negative	HDT Master	50	Perform Enhancements 51 Haze Removal 52 Contrast Stretch 53 Edge Enhancement
13	Film, B & W Positive	HDT Master	72 73 91 92 93 94	Print Histogram Format A CCT BSQ BIL Generate Film Neg. with CCT Generate Film Pos. with CCT
83	CCT*, 9-Track, 800 BPI	HDT Master	Same as above	
84	CCT*, 9-Track, 1600 BPI	HDT Master	Same as above	
97	Pipeline HDT** Processing	HDT Master	(Haze Removal and Contrast Stretch	

Notes: * Any CCT product implies a printed histogram (Process Code 72).
**Pipeline HDT process implies Haze Removal and Contrast Stretch (Process Codes 51 and 52).

Figure 5-1. Work Order Card One (Sheet 2 of 2)



DATA CONTENT OF CARD TWO

GROUP A : CONTROL SECTION (Cols 1-3)

Column	Item/Description	
1	Special Instructions:	Indicates whether special instructions accompany this order. A non-blank code causes message to be printed to EDIPS operator
2	Process Indicator:	Provides program identification of card as EDIPS
3	Card Number:	Indicates card number is 2

GROUP B : PROCESSING PARAMETERS (Cols 4-66)

4-21	Process Codes:	Extension of Process Codes from Card One (Cols 23-32) where more than five processes are required. (See Table I for listing of all process codes)
22-63	Open for future expansion	
64	Reverted/True:	Selects reverted or true mode in the HRFR. In absence of this data, the default (data base) value is used. Codes are: R = Reverted; T = True
65	Table Selection:	Selects one of the tables preloaded in the HRFR. In absence of a code, the default value is used. A code of 9 designates that no table is to be selected (i.e., selects bypass mode of HRFR). Codes are: 1 = Table 1 2 = Table 2 3 = Table 3 4 = Table 4 9 = No table selected (HRFR bypass)
66	Space Forward:	Selects a 4-inch spacing before and after all film images produced for this order. In absence of data, the default (packed space) value is used. Code is: S = Space forward 4 inches

GROUP C : ORDER CONTROL (Cols 67-80)

67-80	Order Number and Unit:	Used by the EDC B6700 to reference this pipeline or special order. EDIPS must use this number for multicard orders to identify all cards pertaining to the same work order.

Figure 5-2. Work Order Card Two

CNTR		CONTRAST STRETCH										HAZE REMOVAL					EDGE ENHANCE			ORDER CONTROL	
			HISTOGRAM CUTOFF SPECIFICATIONS											HISTOGRAM SHIFT							
			BAND 4		BAND 5		BAND 6		BAND 7		BAND 8										
SI	E1	UNIT	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	BAND 4	BAND 5	BAND 6	BAND 7	BAND 8	KERNDF (1)	KERNDF (2)		ORDER NUMBER	UNIT NO.
1 2 3		4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	5 6 7 8 9 0 1 2 3 4	0 1	2 3	4 5 6	7 8 9 0 1 2 3 4 5 6 7	8 9 0
A							B								C				D		E	

DATA CONTENT OF CARD THREE

GROUP A : CONTROL SECTION (Cols 1-3)

Column	Item/Description	
1	Special Instructions:	Indicates whether special instructions accompany this order. A non-blank code causes message to be printed to EDIPS operator
2	Process Indicator:	Provides program identification of card as EDIPS
3	Card Number:	Indicates card number is 3

GROUP B : CONTRAST STRETCH PARAMETERS (Cols 4-44)

4	Unit:	Selects unit of measure for contrast stretch values that follow. Values are: G = Grey Level; P = Percent
5-44	Min/Max:	In the units specified by column 4, specifies manually selected Min/Max values for the respective histogram cutoffs. Range of values are: Grey Level = 0000-0255 Percent = 0.000% - 9.999% (where decimal point is implied)

GROUP C : HAZE REMOVAL PARAMETERS (Cols 45-59)

45-59	Histogram Shift:	Specifies respective shifts to be made in the histograms for each band as manually selected. Shift is assumed to be to the left, or to lower values. Value ranges in grey levels are 0 - 255

GROUP D : EDGE ENHANCEMENT (Cols 60-66)

60-63	Kernel Size:	Specifies M (no. of lines), N (pixels) of value for kernel (picture) size to be employed in the edge enhancement algorithm. Range of M,N is 1 to 9
64-66	Open for future expansion	

GROUP E : ORDER CONTROL (Cols 67-80)

67-80	Order Number and Unit:	Used by the EDC B6700 to reference this pipeline or special order. EDIPS must use this number for multicard orders to identify all cards pertaining to the same work order.

Figure 5-3. Work Order Card Three

2. Only a Product Code of 03 or 13 can be specified for CCT input (Tape Type = C). No Process Codes can be specified. Only CCT's containing corrected data should be input.

3. Only a Product Code of 83 or 84 can be specified for HDT-A input (Tape Type = H; Type = A). For MSS only, a Process CODE of 91 or 92 must be specified to provide the interleaving type. No other process Codes can be specified and, for RBV, a process code of 91 or 92 is considered an error.

4. A Process Code of 50 is undefined and should not be used.

5. A Process Code of 74 (Format B) is no longer applicable and should not be used.

6. A Product Code of 98 (HDT copy) should not be used since this is performed off-line and does not involve EDIPS processing.

7. A Process Code of 93 or 94 can be used only when the Product Code is 83 or 84 and for special order processing with a HDT-P (Tape Type = H; Type = P) input.

8. Process Codes of 51, 52, 53, and 72 can be used with a Product Code of 03, 13, 83 or 84 for special order processing with a HDT-P input. When both 51 and 52 are used, they must be specified as a pair (i.e., specified as contiguous Process Code entries). However, they may be specified in the order 51, 52 or 52, 51 to designate the order in which haze removal and contrast stretch are to be performed. If Process Code 53 occurs before 51/52 (only one or both in either order), edge enhancement will be performed before the haze removal/contrast stretch correction is applied. If the 51/52 occurs before 53, the haze removal/contrast stretch correction will be applied before the edge enhancement. Note that the haze removal/-contrast stretch correction is based on the histogram of input pixel values regardless of where the correction is applied.

5-4. HIGH DENSITY TAPE FORMATS

The HDTs produced by NASA/GSFC are classified by two major image data distinctions based on sensor type (MSS or RBV), and whether the image data have geometric corrections

applied or not. All HDT formats have data which have been radiometrically corrected. Four types of HDTs result:

- HDT_{PM} - MSS data with geometric correction applied
- HDT_{PR} - RBV data with geometric correction applied
- HDT_{AM} - MSS data without geometric correction applied
- HDT_{AR} - RBV data without geometric correction applied

For each of these types there is a corresponding Interface Control Document (ICD) which completely describes the tape, including details of both the image and associated data. These ICDs are identified in the discussions below, in which the formats of each HDT are summarized.

The general format of an HDT is illustrated in Figure 5-4. A major frame contains 8 minor frames for MSS data and 12 minor frames for RBV data. The length of a major frame was computed to contain one image data scanline plus the accumulated lengths of the quality/calibration data and other codes necessary for operation and identification (e.g., sync patterns, minor frame counts, minor frame type codes, and scanline identifiers). The length of a major frame remains constant within a reel of tape.

5-5. HDT_{PM}

The HDT_{PM} tapes contain MSS data which have been corrected for system radiometric and geometric anomalies. Each image (MSS scene) contains four groupings of information: header, annotation, image, and trailer data. The images are separated by preamble/filler data, and a tape directory frame appears once at the beginning of each reel of tape. The key to understanding, interpreting, and utilizing these data is found in the input data type headers.

a. Header Data - Contains HDT_{PM} identification, spacecraft identification, time of image exposure, and all data-set identification/characteristics. These data are used to identify the scenes of the image data and to provide the information required to interpret data in the other sections of the tape.

b. Annotation Data - Contains all alphanumeric and identification data required for film image generation.

c. Image Data - Contains the NASA/GSFC outputted image data as well as quality information for each scanline. The quality data indicate status (i.e., whether a scanline has been replaced at NASA/GSFC). Figure 5-5 illustrates one major frame of image data.

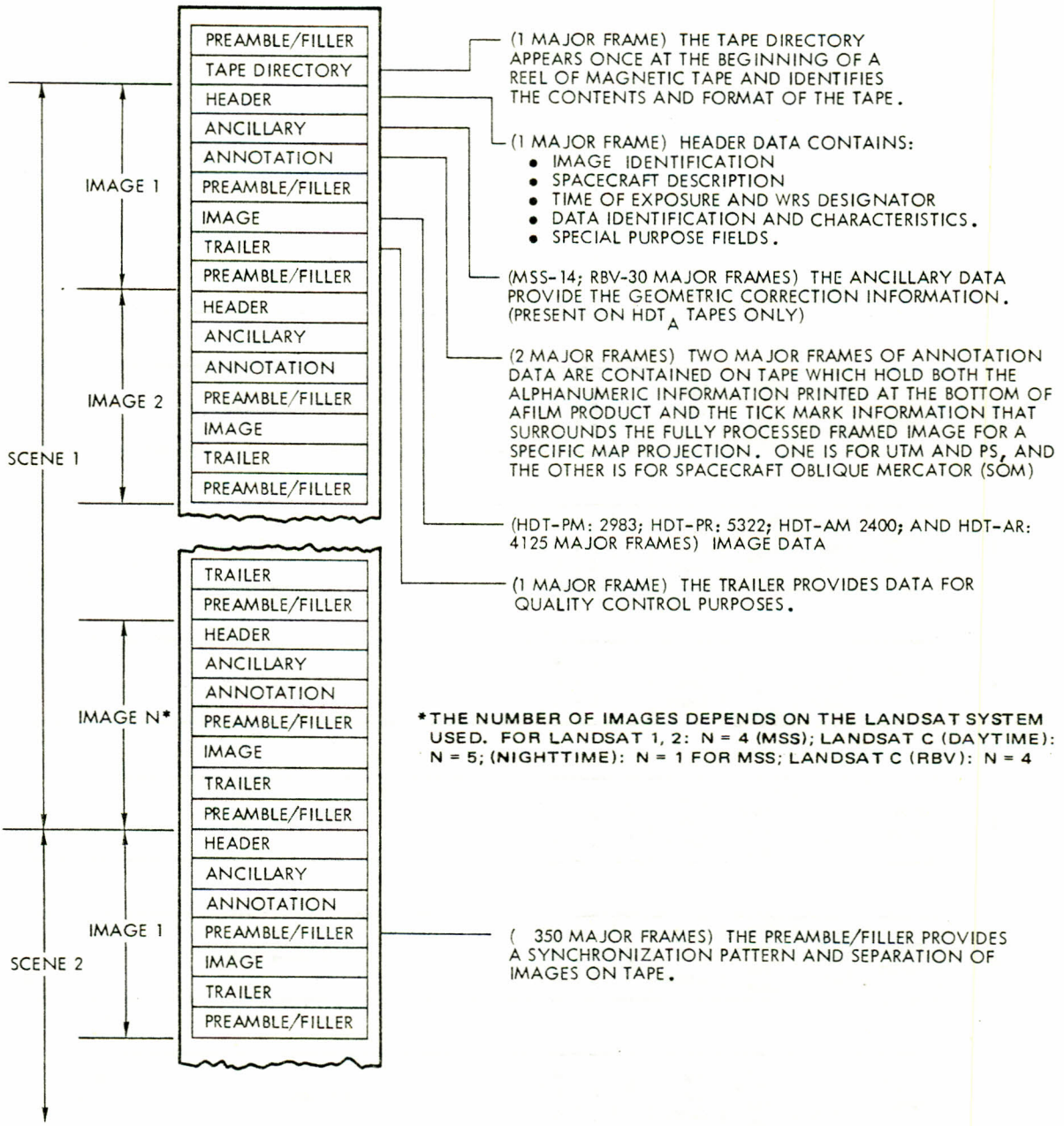


Figure 5-4. General Format of HDT

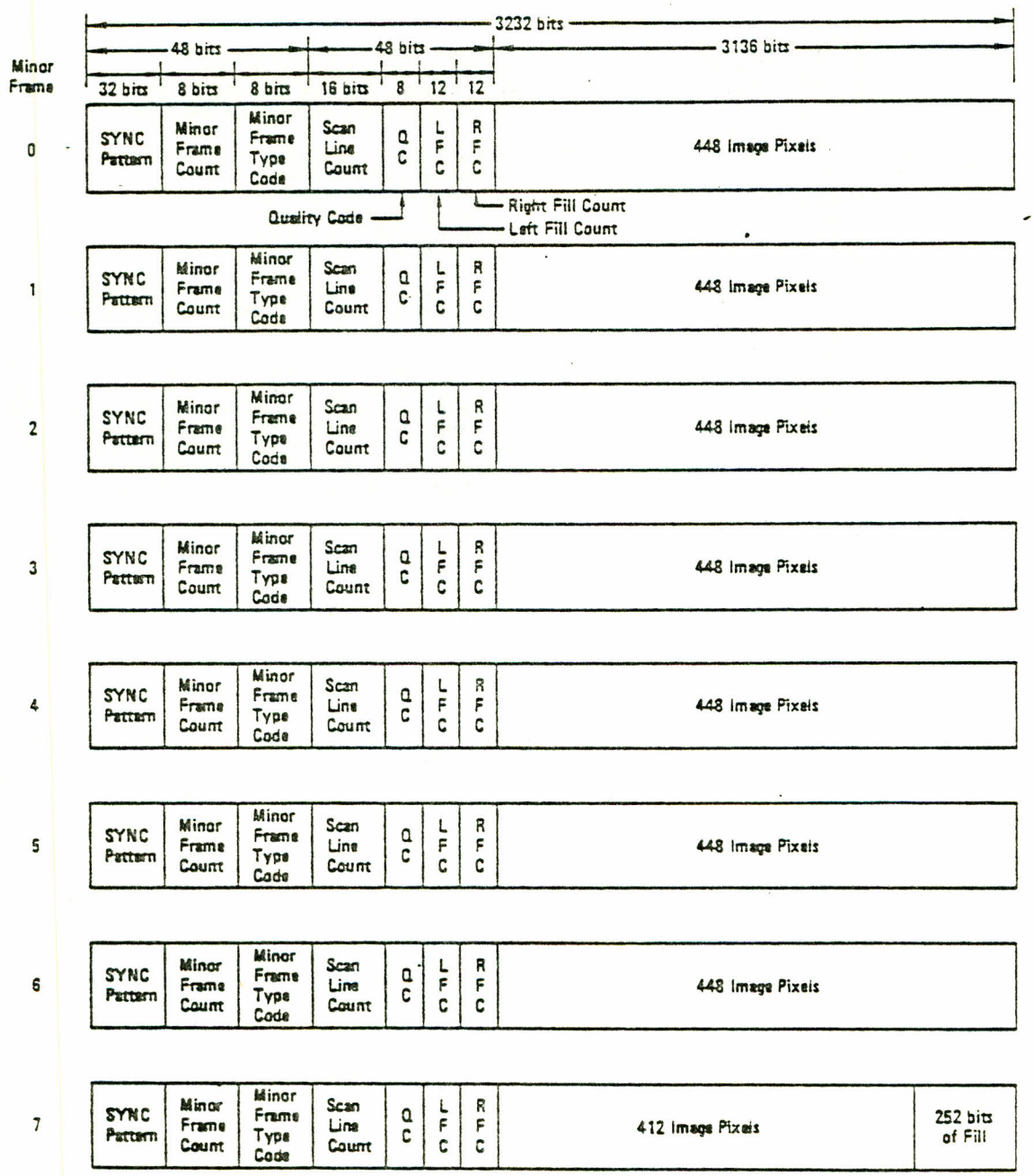


Figure 5-5. One Major Frame of HDT_{PM} Image Data

d. Trailer Data - Contains information related to the specific quality for the frame.

e. Preamble/Filler - Placed on the tape primarily to ensure the proper operation of the recorder in the playback mode, and to separate each image. Each minor frame consists of alternating 1s and 0s (1010101010...) and is repeated the number of times required to complete a major frame. A minor frame of preamble/filler begins with the 6 bytes of standard identification data (sync pattern,minor frame count, and minor frame type code) and is completed with the preamble/filler pattern.

A full description of the contents, format, and placement of all data on the HDT_{PM} tapes can be found in the following documents: Interface Control Document Between the Image Processing Facility and EDC Digital Image Processing System for LANDSAT - Fully Processed Multispectral Scanner High Density Tape (HDT-PM/PMC). Dated 25 February 1977; Document No. IPF-ICD-206. NASA, Goddard Space-Flight Center, Greenbelt, Maryland.

5-6. HDT_{PR}

The HDT_{PR} tapes contain image data produced by the RBV cameras in the LANDSAT C satellites. The RBV scenes cover the same approximate terrestrial area as one MSS scene (nominally, 182.5 km crosstrack x 180 km spacecraft direction), but the RBV scene is composed of four subscenes which divide this area into four roughly equal quadrants (Figure 5-6). The subscenes are recorded sequentially (A,B,C,D) on the tapes.

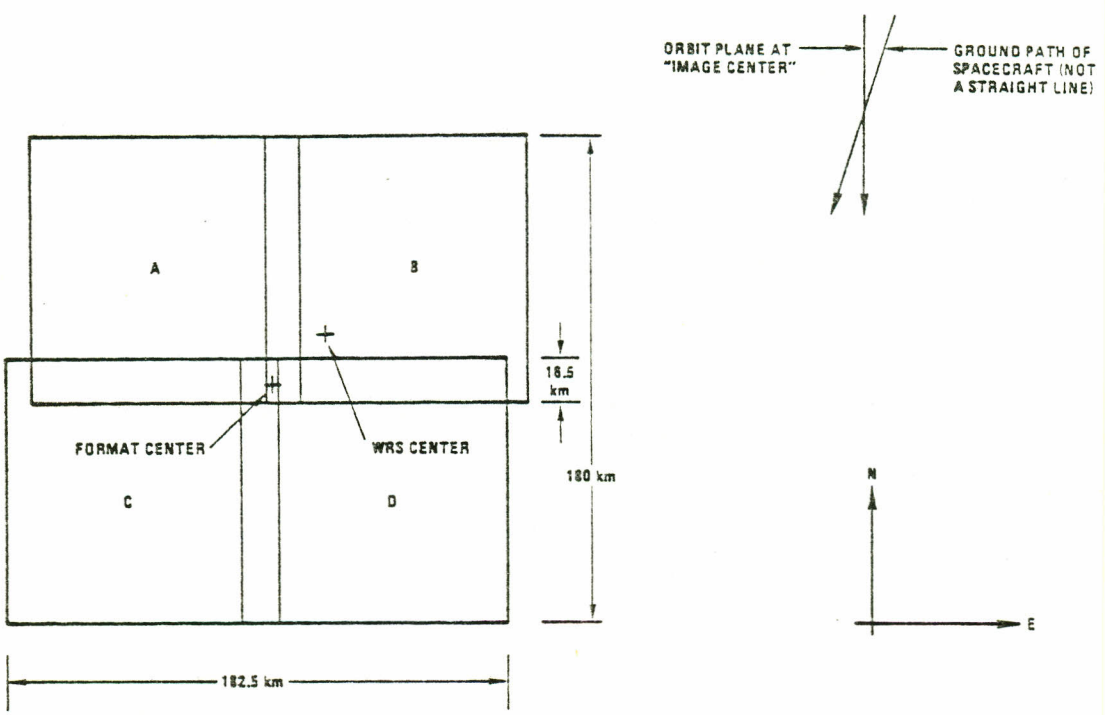


Figure 5-6. RBV Subscenes - LANDSAT C

A reel of HDT can contain up to 20 RBV scenes with four subscenes per scene. The general format of the HDT_{PR} tapes consists of header, annotation, preamble/filler, image, and trailer data for each RBV image. Each RBV image is separated by preamble/filler data. Refer to Figure 5-4 (On that figure, image N* = 4 for LANDSAT C satellites). The RBV image data on the HDT_{PR} represents a rectangular RBV data array which is 5,322 pixels by 5,322 scan lines.

A major frame on RBV tapes contains 12 minor frames, and its value (i.e., the number of minor frames per major frame) is specified in the header data section. Figure 5-7 illustrates one major frame of HDT_{PR} image data. As for the MSS, the length of an RBV major frame was computed to contain one image data scanline, plus the accumulated lengths of codes necessary for operation and identification. The length of a major frame remains constant with a reel of tape.

A full description of the HDT_{PR} tapes is provided in the following document: Interface Control Document between the Image Processing Facility and EDC Digital Image Processing System for LANDSAT - Fully Processed Return Beam Vidicon High Density Tape (HDT-PR/PRC). Dated 15 April 1977; Document No. IPF-ICD-207; NASA/GSFC, Greenbelt, Maryland.

5-7. HDT_{AM}

The HDT_{AM} tapes contain data which has only been corrected for system radiometric anomalies. Geometric correction has not been done. Each image contains five groups of information: header, image, annotation, ancillary, and trailer data. The ancillary data provide the geometric correction information. Figure 5-8 illustrates one major frame of image data.

A full description of these tapes is provided in the following document: Interface Control Document between the Image Processing Facility and EDC Digital Image Processing System for LANDSAT - Partially Processed Multispectral Scanner High Density Tape (HDT-AMC). Dated 15 April 1977; Document No. IPF-ICD-201. NASA/GSFC, Greenbelt, Maryland.

5-8. HDT_{AR}

The RBV image data on HDT_{AR} tapes has been radiometrically corrected, but geometrically uncorrected (i.e., corrections due to spacecraft altitude, ground truth, scan non-linearity, map projection, etc. have not been applied). However, all of the necessary data sets needed to perform the geometric corrections are present on these tapes in the ancillary data frames.

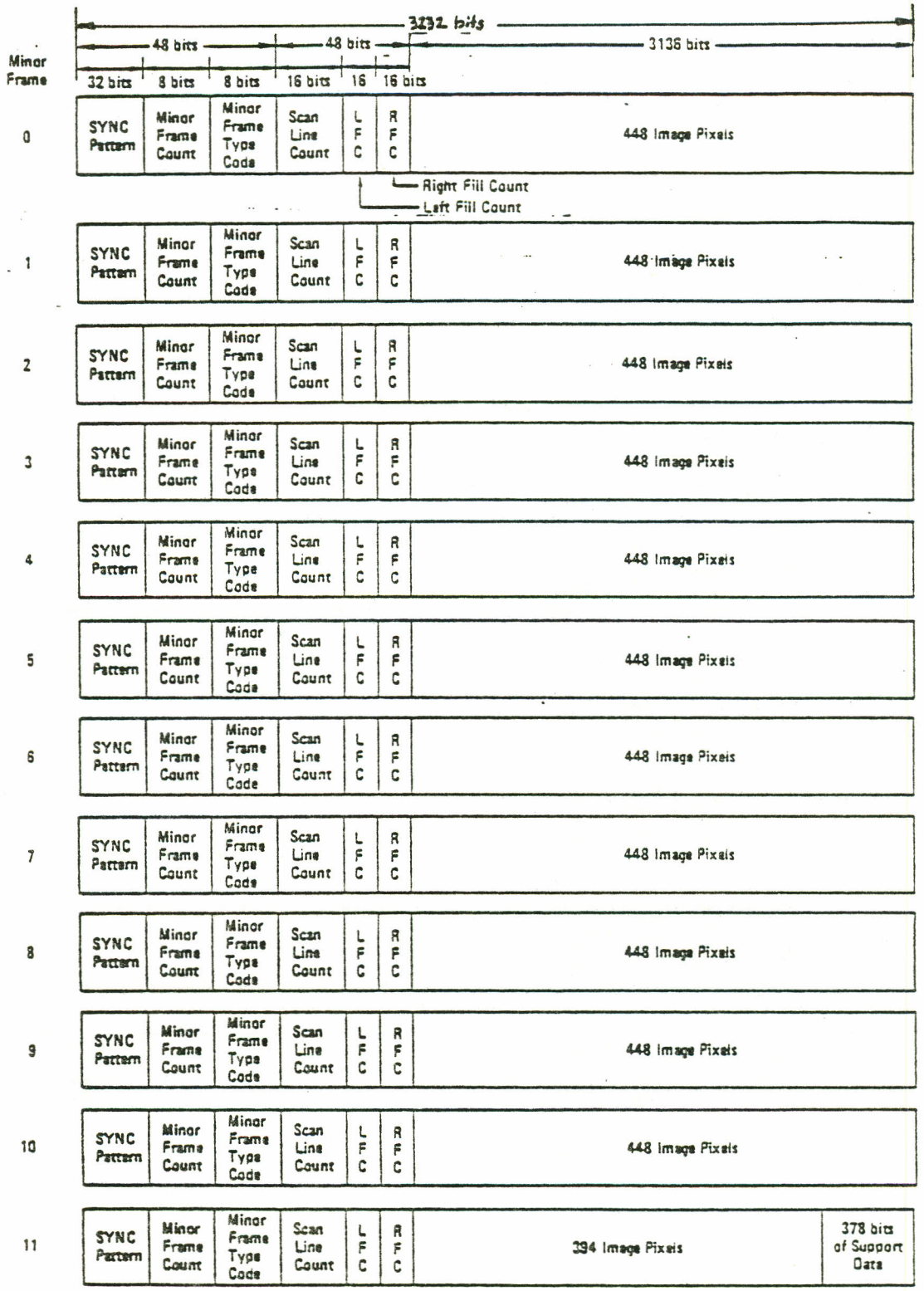


Figure 5-7. One Major Frame of HDT_{PR} Image Data

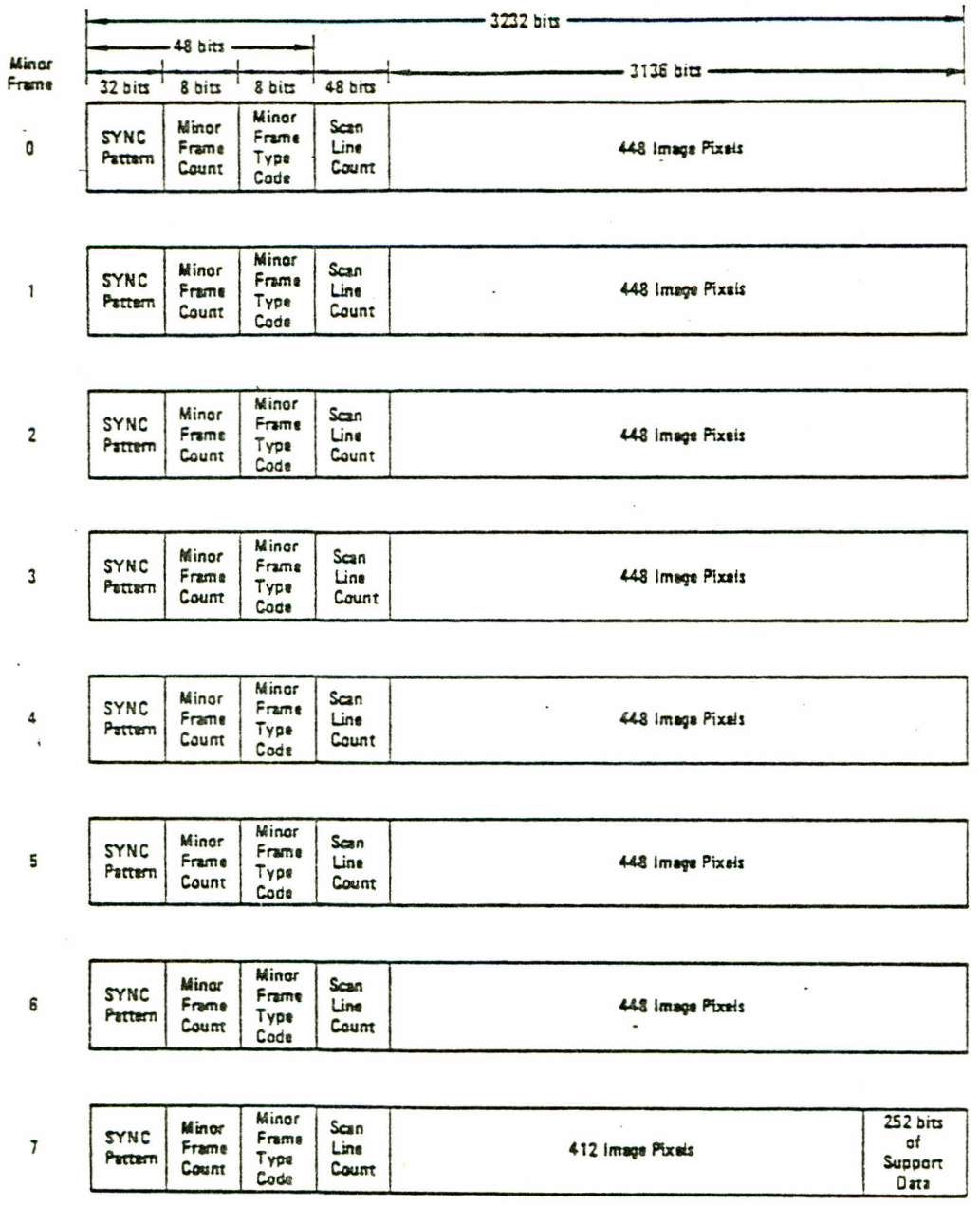


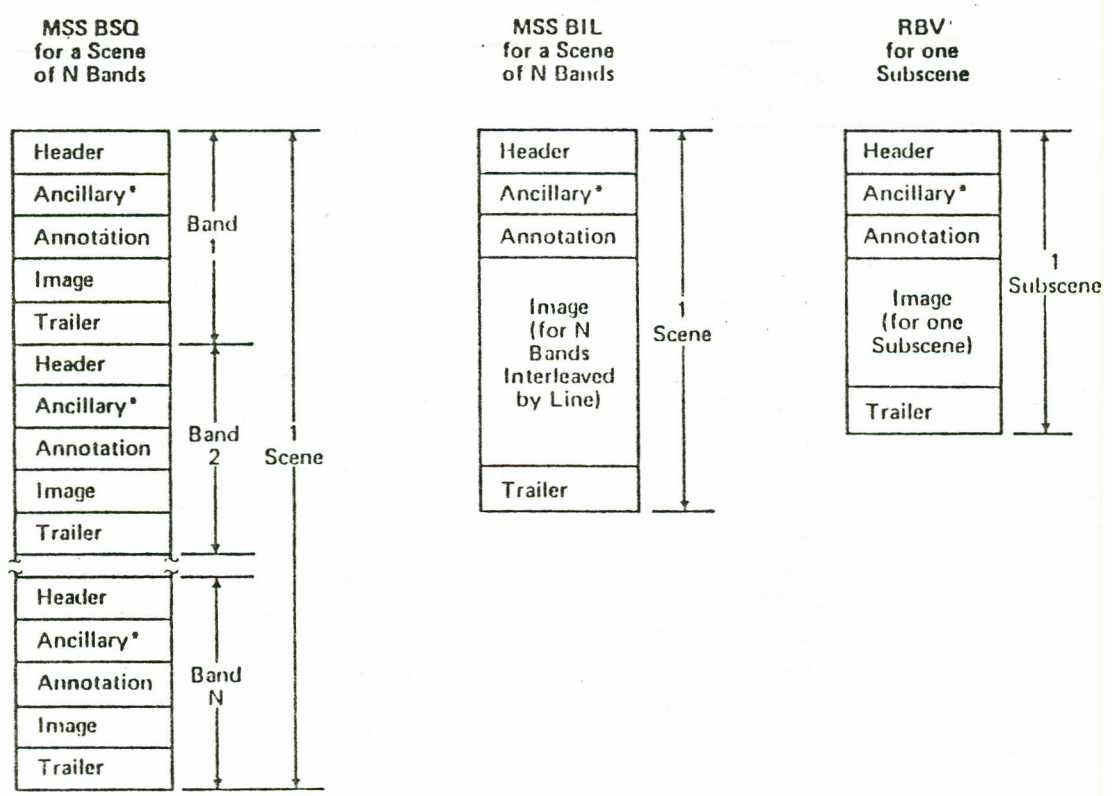
Figure 5-8. One Major Frame of HDT_{AM} Image Data

All HDT_{AR} tapes contain seven types of major frames: preamble/filler, tape directory, header, ancillary, annotation, image, and trailer. Each major frame contains 12 minor frames (see Figure 5-7).

A full description of the HDT_{AR} tapes is provided in the following document: Interface Control Document between the Image Processing Facility and EDC Digital Image Processing System for LANDSAT - Partially Processed Return Beam Vidicon High Density Tape (HDT-AR/ARC). Dated 15 April 1977; Document No. IPF-ICD-202; NASA/GSFC, Greenbelt, Maryland.

5-9. CCT FORMAT

For users who desire image data in digital form rather than on film, EDIPS produces digital data on 9-track computer compatible tapes (CCTs) at 800 and 1600 BPI. CCTs produced by EDIPS may contain any of the four types of HDT data (HDT_{PM}, HDT_{PR}, HDT_{AM}, or HDT_{AR}). MSS CCTs are produced with image data in either a Band Interleaved by Line (BIL) or a Band Sequential (BSQ) pattern. RBV data are produced on a per subscene basis only. Although each of these types of CCTs may require varying numbers of records and tape reels, there is a general data format which applies to all CCTs as shown in Figure 5-9.



*Present on CCT's with geometrically uncorrected data only.

Figure 5-9. Data Format of CCTs

5-10. RELATIONSHIP BETWEEN CCT RECORDS AND HDT MAJOR FRAMES

Records on CCTs have one-to-one correspondence to major frames of data on HDTs. Tape directory, header, ancillary, annotation, image, and trailer data occupy separate sets of records. As shown in Figure 5-10, records are structured to contain a record number, a zero fill byte, a record type code, data, and optional zero fill. Records are separated by Inter-Records gaps (0.5-0.6 inches), and are not split between reels of CCT.

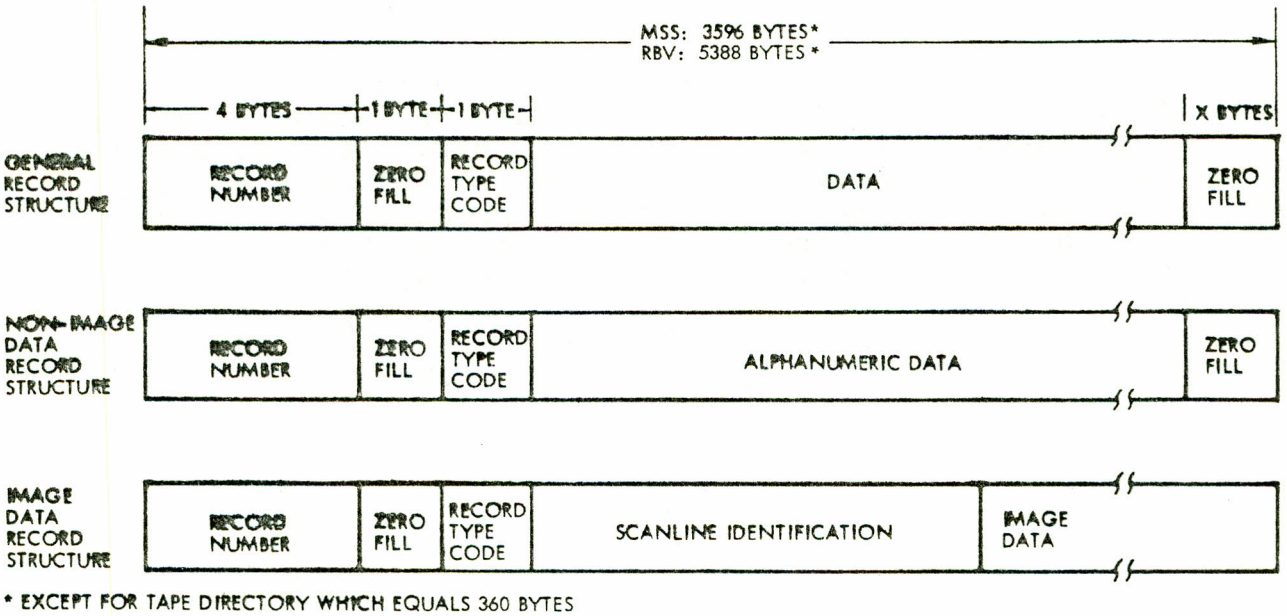


Figure 5-10. Standard CCT Record Structure

CCTs are of constant physical record length, and that length depends on sensor alone. The general translation from HDT major frames to CCT records is illustrated on Figure 5-11 for image data, and on Figure 5-12 for non-image data. The mapping of image data from major frame to record is also the method for determining CCT record length. In Figure 5-11, one image frame is composed of M minor frames of equal length, and each minor frame is composed of 12 bytes of introductory data and N 7-bit pixels (or N-n 7-bit pixels plus n 7-bit support or zero fill words in the last minor frame). The CCT record is constructed by changing the first 12 bytes of HDT introductory data to the 12 bytes of CCT introductory data. Then each of the N x M 7-bit pixels (or words) are padded to become N x M 8-bit pixels (or words) which follow the introductory data in the CCT record. CCT record length is thus 12 + (N x M) bytes.

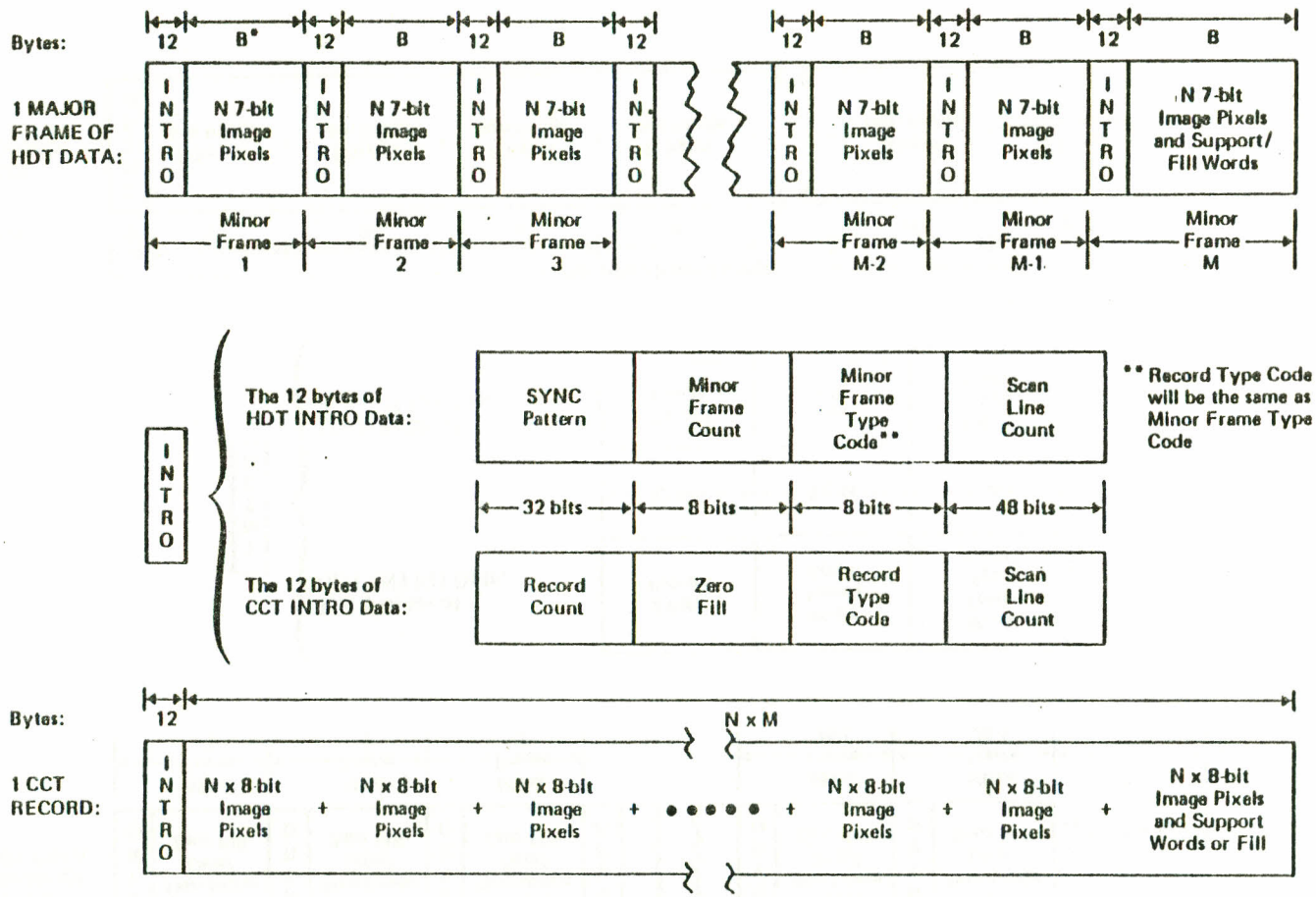


Figure 5-11. Translation of One HDT Major Frame of Image Data to One CCT Record of Image Data

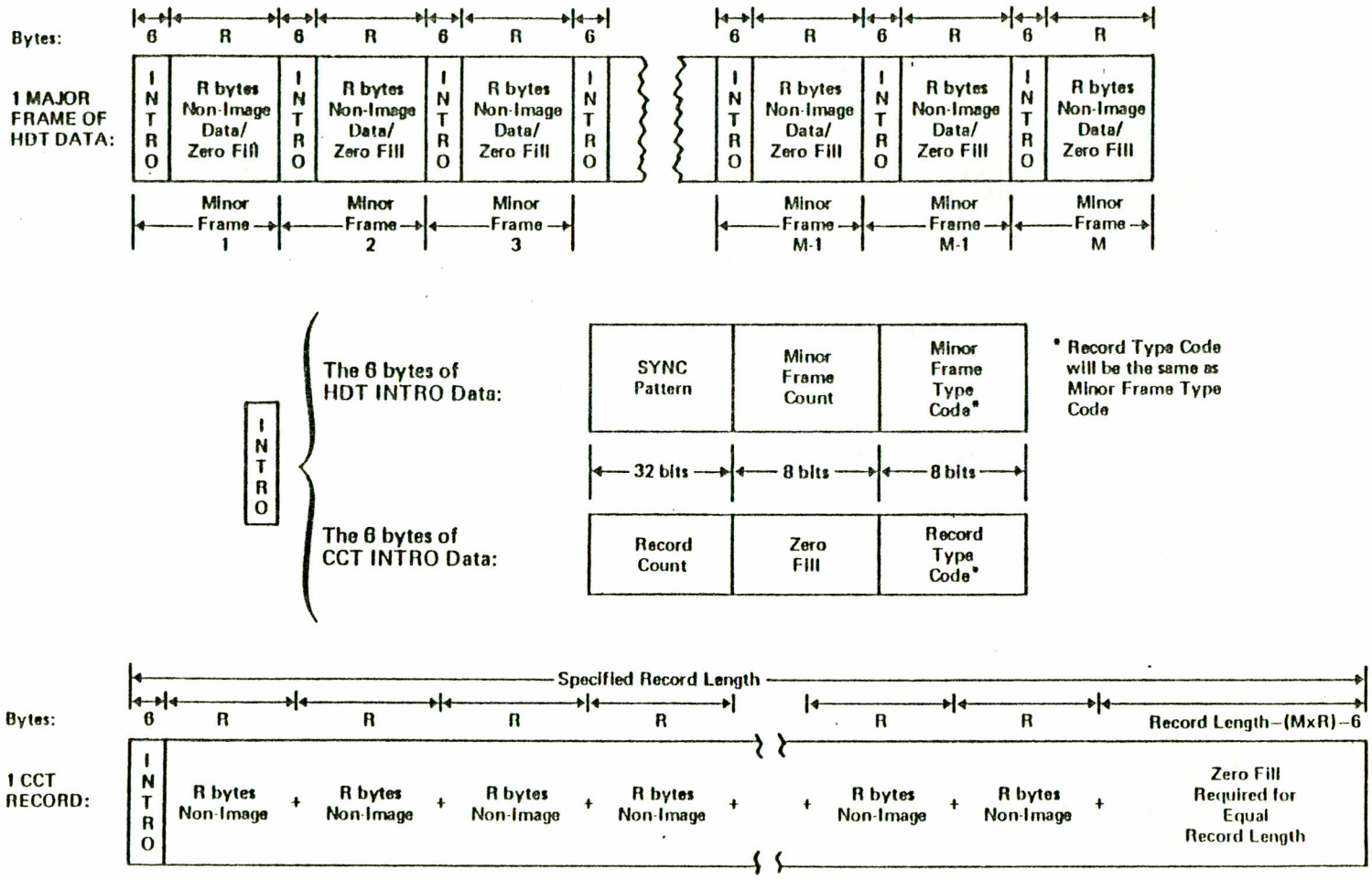


Figure 5-12. Translation of One HDT Major Frame of Non-Image Data to One CCT Record of Non-Image Data

Record length having thus been established, all other types of data records are constructed as shown in Figure 5-12. Here, the major frame contains M minor frames of 6 + R bytes each. The CCT record is constructed by changing the 6 bytes of HDT standard non-image introductory data to the 6 bytes of introductory data. This is followed by the M x R bytes of data, with each of the R bytes recorded in the same order and with the same bit appropriation as defined in the appropriate HDT format.

5-11. CCT IMAGE DATA

The image data section of CCTs contains introductory data as well as the actual sensor data, as shown on Figure 5-11. Each record contains sensor data representing one scan line plus the support data associated with that scan line. The header specifies the characteristics of the image data, including the number of pixels (sensor samples) per scan line, interleaving, etc. The content of the image data section depends on the interleaving and correction status of the data.

CCTs may have image data arranged in a Band Sequential (BSQ) pattern or in a Band Interleaved by Line (BIL) pattern. Figure 5-13 illustrates these two interleaving patterns.

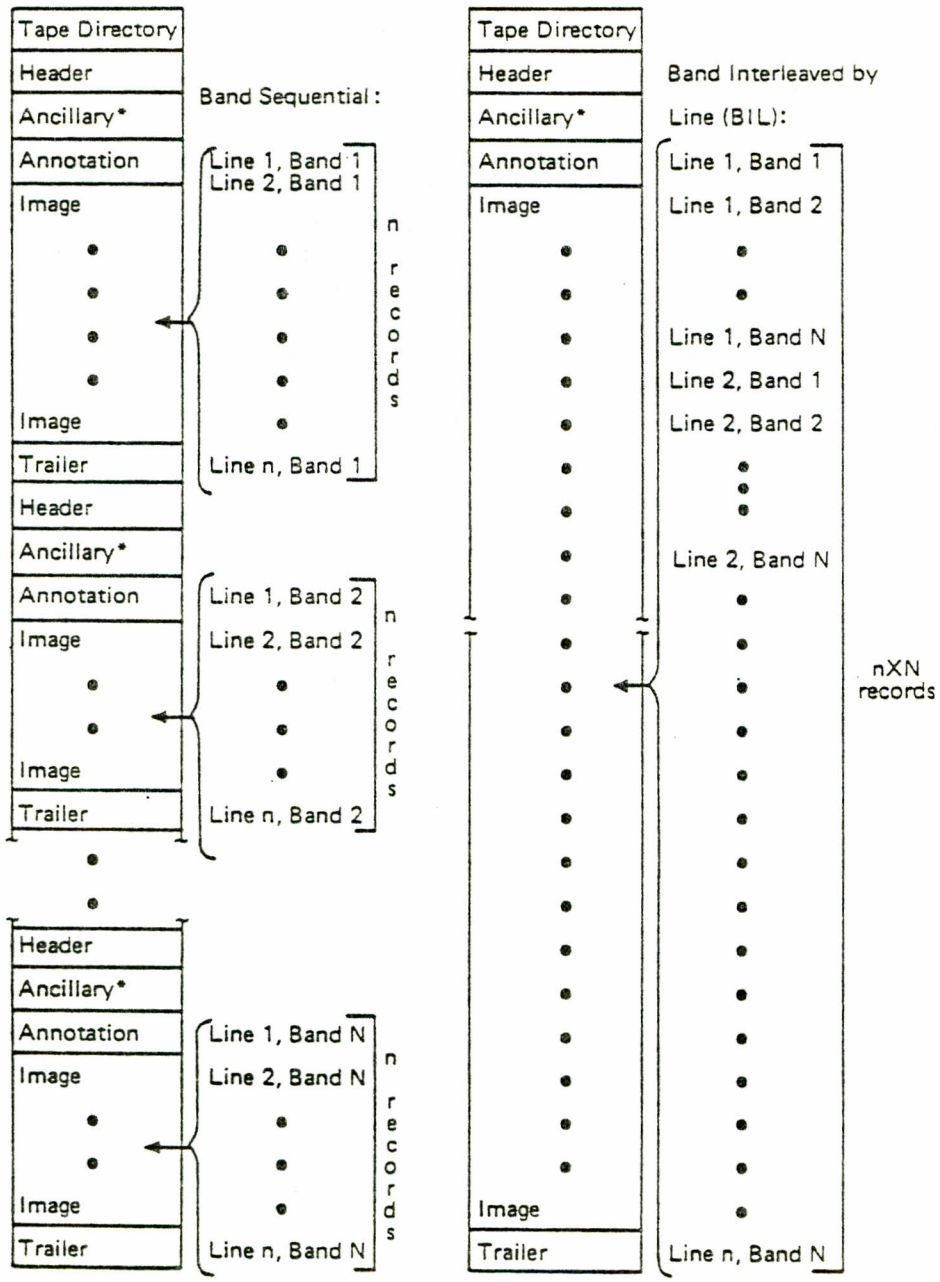
a. Band Sequential (BSQ)

In the BSQ pattern, the image data for each band are given in a separate image data section. The ordering of records on a CCT is thus exactly the same as the ordering of major frames on an HDT.

b. Band Interleaved by Line (BIL)

In the BIL pattern, the image data for all bands are in one image data section. If the data for a band are missing, that band will be zero filled. Since each record still contains one line of one band (or zeros representing one line of a band), record length is not affected by the change in interleaving. However, while each band of BSQ requires header, annotation, ancillary (if geometrically uncorrected), and trailer data, one set of these non-image sections is sufficient for all bands (now combined in one image section) of BIL. Therefore, there will be fewer records per scene of BIL than of BSQ.

Depending on factors such as sensor, interleaving, density, etc., one EDIPS scene (image) may require more than one CCT reel. Table 5-1 lists the image break points for each of the possible types of data configurations.



*Present only on CCT's with geometrically uncorrected data.

Figure 5-13. Examples of Interleaving of MSS Image Data of N Bands of n Lines Each

Table 5-1. Image Break Points

Data Type and Tape Number	Image Distribution by Density	
	800 BPI	1600 BPI
RBV		
Geometrically Uncorrected		
Tape 1	2062 lines	entire image
Tape 2	remaining image lines	
Geometrically Corrected		
Tape 1	2661 lines	entire image
Tape 2	2661 lines	
MSS BSQ		
Geometrically Uncorrected		
(1 band) Tape 1	entire image	entire image
(2 bands) Tape 1	band 1	all images
Tape 2	band 2	
(3 bands) Tape 1	bands 1 and 2	all images
Tape 2	band 3	
(4 bands) Tape 1	bands 1 and 2	all images
Tape 2	bands 3 and 4	
(5 bands) Tape 1	bands 1 and 2	bands 1, 2, and 3
Tape 2	bands 3 and 4	bands 4 and 5
Tape 3	band 5	
Geometrically Corrected		
(1 band) Tape 1	entire image	entire image
(2 bands) Tape 1	band 1	all images
Tape 2	band 2	
(3 bands) Tape 1	band 1 and 1491 lines of band 2	all images
Tape 2	1492 lines of band 2 and band 3	

Table 5-1. Image Break Points (Continued)

Data Type and Tape Number	Image Distribution by Density	
	800 BPI	1600 BPI
(4 bands) Tape 1	band 1 and 1491 lines of band 2	bands 1 and 2
Tape 2	1492 lines of band 2 and band 3	bands 3 and 4
Tape 3	band 4	
MSS BSQ		
Geometrically Corrected		
(5 bands) Tape 1	band 1 and 1987 lines	bands 1, 2, and 3
Tape 2	996 of 2, band 3, and 996 of 4	bands 4 and 5
Tape 3	1987 lines of band 4, band 5	
MSS BIL		
Geometrically Uncorrected		
(4 bands) Tape 1	4800 lines	all lines
Tape 2	4800 lines	
(5 bands) Tape 1	4000 lines	6000 lines
Tape 2	4000 lines	6000 lines
Tape 3	4000 lines	
Geometrically Corrected		
(4 bands) Tape 1	3976 lines	5964 lines
Tape 2	3976 lines	5968 lines
Tape 3	3980 lines	
(5 bands) Tape 1	4970 lines	7455 lines
Tape 2	4970 lines	7460 lines
Tape 3	4975 lines	

The following constraints apply to the image breaks:

- Header, annotation, ancillary and trailer blocks are not mentioned, but are assumed to be on the tapes in the formats previously defined

- Tape break points are on an integral record boundary and only in image sections or after an EOF on an entire band

- Break point of image sections is done:

  a) With equal distribution, or if it doesn't divide evenly, then the lower number goes on the first tape with the residual on the last;
  b) If BIL format, the number of records must be divisible by the number of lines interleaved.

A full description of CCTs is provided in the following document: Interface Control Document between the Image Processing Facility and EDC Digital Image Processing System for LANDSAT - IPF/EDIPS Computer Compatible Tapes (CCTs). Dated 6 June 1977; Document No. IPF-ICD-116; NASA/GSFC, Greenbelt, Maryland.

5-12. FILM FORMAT

The EDIPS processes MSS image data to 1:1 aspect ratio in an array size of 3548 pixels x 2983 lines per band to produce 1:1,000,000 scale HRFR film images. The on-film MSS pixel spacing is 0.057 mm, representing 57 meters on the ground. The EDIPS processes RBV image data to a 1:1 aspect ratio in an array size of 5322 pixels x 5322 lines per sub-scene to produce 1:500,000 scale HRFR film images. The on-film RBV pixel spacing is 0.038 mm, representing 19 meters on the ground. These array include "one's" fill resulting from geometric corrections which have been previously applied to the HDT_P data by NASA/GSFC.

In addition, EDIPS rasterizes and merges the required film annotation data (and inter-frame "gap" data) with the ground image data to form a composite group of digital image data to be outputted to and recorded on film by the HRFR. The resulting film product appears as shown in the black and white print on Figure 5-14. The composite output MSS image array size is 3620 pixels x 3385 lines (plus 660 lines of "gap" data) per band, and the composite output RBV image array size is 5428 pixels x 5906 lines (plus 1003 lines of "gap" data) per subscene.

In the pipeline film mode, EDIPS commands output data to the HRFR such that there is no "noise" or unrecorded gaps; however, the EDIPS generates a nominal 1-1/2 inch gap between all image frames with the laser unblanked in the

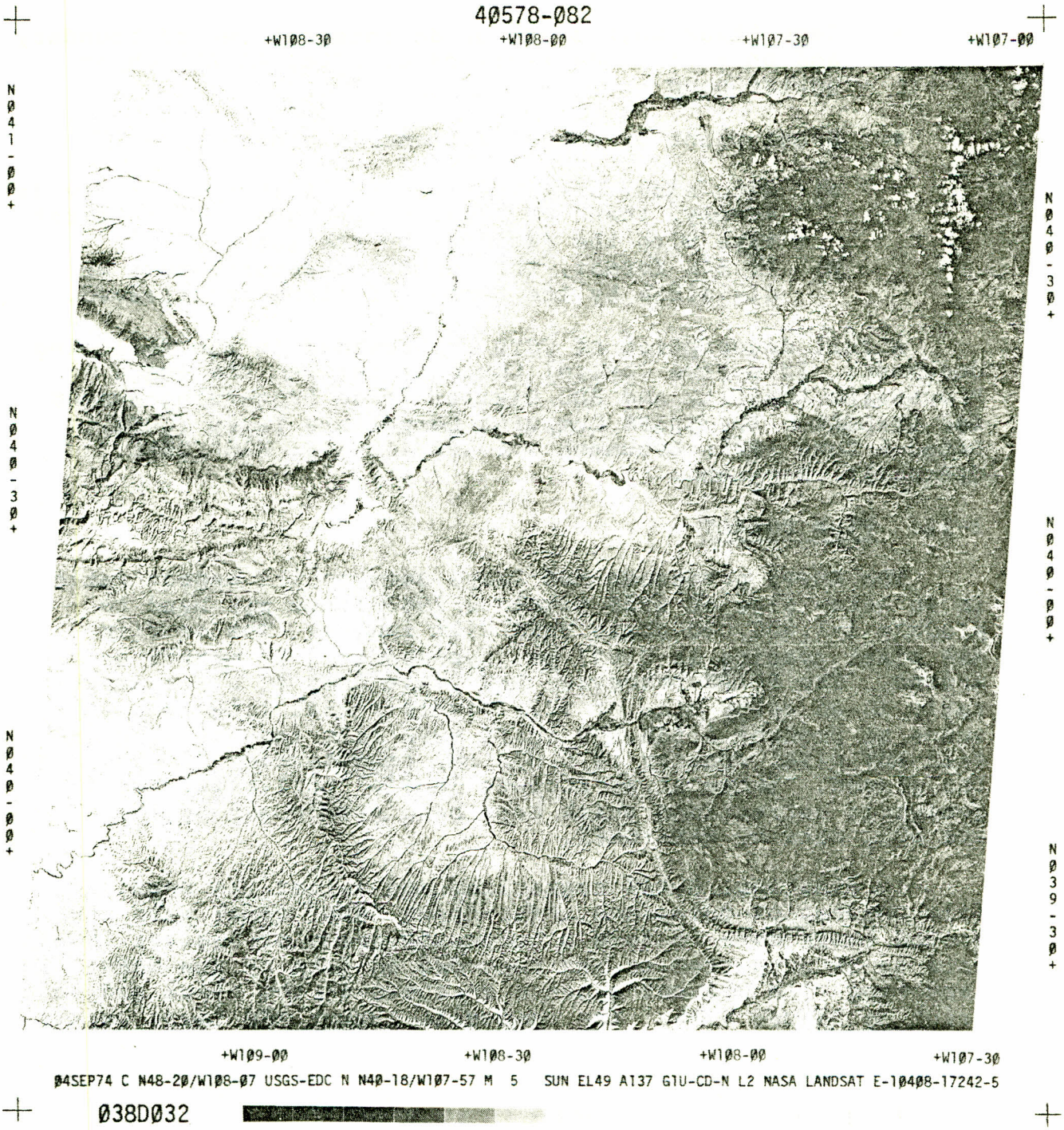


Figure 5-14. Typical EDIPS Film Product

NEG mode and blanked in the POS mode, i.e., EDIPS transfers one's fill, with the possibility of up to 5 noise scanlines at the center of the gap between scenes or subscenes. This is also true for the special order film mode, excepting that a WOC SPACE FORWARD command produces a film gap of 3-3/4 ±1/4 inches between film image frames with laser operation the same as during the 1-1/2 inch gaps.

5-13. MSS IMAGES

The overall MSS video data recording format is band sequential. There are eight binary coded bits per byte (pixel) and one image, annotation or filler line per film line. A byte may have 6,7 or 8 active bits which EDIPS always shifts to the most significant end of the 8-bit byte before outputting to the HRFR, putting zeros in the right-most bits. Within the image field of video data, a line consists of 3548 image bytes (pixels) plus 72 side annotation bytes, for a total of 3620 bytes per output line. Similarly, there are 3620 bytes per line within the video data fields containing top/bottom annotation. There are 2983 ground image lines per band plus 402 top/bottom annotation lines and 660 "gap" lines for a total of 4045 lines per output band image. There are five MSS bands (four bands for LANDSAT 1 and 2 data) per scene. The format for one band of MSS data is given in Table 5-2. Line formats for the two different types of MSS video image data are given in Table 5-3. A typical MSS film recording is illustrated in Figure 5-15.

5-14. RBV IMAGES

The overall film recording format for LANDSAT subscene RBV video data is subscene sequential. There are eight binary coded bits per byte (pixel) and one image, annotation or filler line per film line. A byte may have 6,7 or 8 active bits which EDIPS shall always shift to the most significant end of the 8-bit byte before outputting to the HRFR. Within the ground image field of the video data, a line consists of 5322 image bytes (pixels) plus 106 side annotation bytes, for a total of 5428 bytes per output line. Similarly, there are 5428 bytes per line within the video data fields containing top/bottom annotation. There are 5322 ground image lines per subscene plus 584 top/bottom annotation lines and 1010 "gap" lines for a total of 6916 lines per output subscene image. The format for one RBV subscene is given in Table 5-4. Line formats for the two different types of LANDSAT subscene RBV video image data are given in Table 5-5. A typical HRFR RBV film recording is illustrated in Figure 5-16 (for 1:500,000 scale images).

Table 5-2. HRFR Film, MSS Band Format

Line Nos.	Description	Total No. of Lines	Type
1-330	Top "gap" lines	330	B
331-359	Filler Lines	29	B
360-477	Top Registration Marks, Roll/Frame No. (see Note 1)	118	B
478-497	Filler Lines	20	B
498-528	Top Annotation/Tick Marks (see Note 3)	31	B
529-530	Filler Lines	2	B
531-3513	Ground Image, "One's" Fill	2983	A
3514-3515	Filler Lines	2	B
3516-3546	Bottom Annotation/Tick Marks (see Note 3)	31	B
3547-3556	Filler Lines	10	B
3557-3587	ID	31	B
3588-3597	Filler Lines	10	B
3598-3715	Bottom Registration Marks, Path/Row No. (see Note 2), Gray Scale	118	B
3716-4045	Bottom "gap" Lines	330	B

NOTES:

1. Roll/Frame No.: Line nos. 360-452 (93 total lines).
2. Path/Row No.: Line nos. 3623-3715 (93 total lines), except that the "A" or "D" designations are line nos. 3654-3684 (31 total lines).
3. Tick Marks: Occupy the center 21 lines.

Table 5-3. HRFR Film, MSS Line Formats

Byte Nos.	Description	Total No. of Bytes
TYPE A - TYPICAL IMAGE LINE		
1-8	Filler Bytes	8
9-39	Left Side Annotation/Tick Marks	21
30-36	Filler Bytes	7
37-3584	Ground Image, "One's" Fill Bytes	3548
3585-3591	Filler Bytes	7
3592-3612	Right Side Annotation/Tick Marks	21
3613-3620	Filler Bytes	8
TYPE B - TYPICAL ANNOTATION LINE		
1	Filler Line	1
2-119	Left Registration Mark or Filler Bytes	118
120-3501	Filler Bytes and Roll/Frame No., or Path/Row No. and Gray Scale, or ID, or Filler Lines	3382
3502-3619	Right Registration Mark or Filler Bytes	118
3620	Filler Line	1

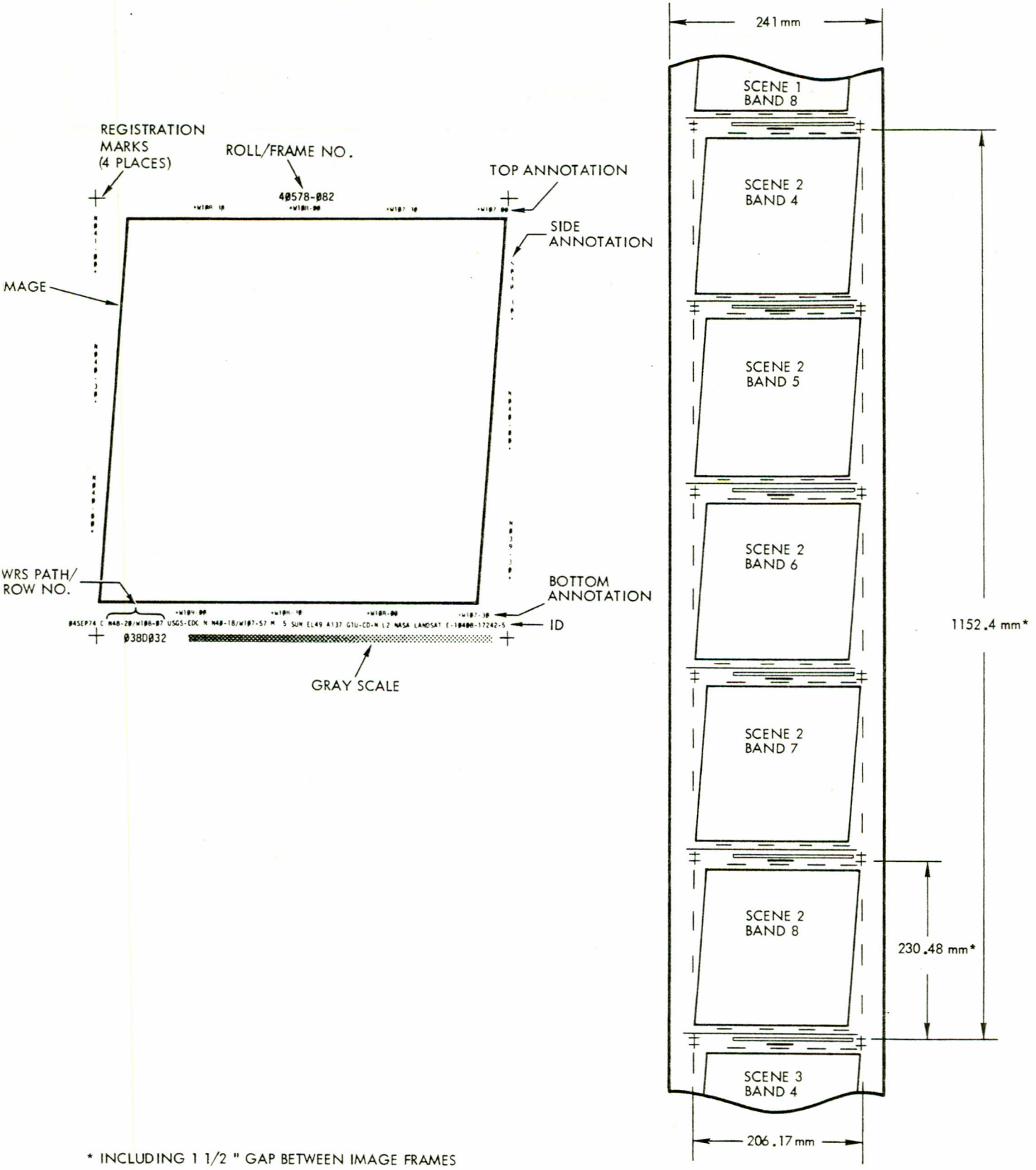


Figure 5-15. LANDSAT C MSS Typical Film Recording (For 1:1,000,000 Scale Images)

Table 5-4. HRFR Film, RBV Subscene Format

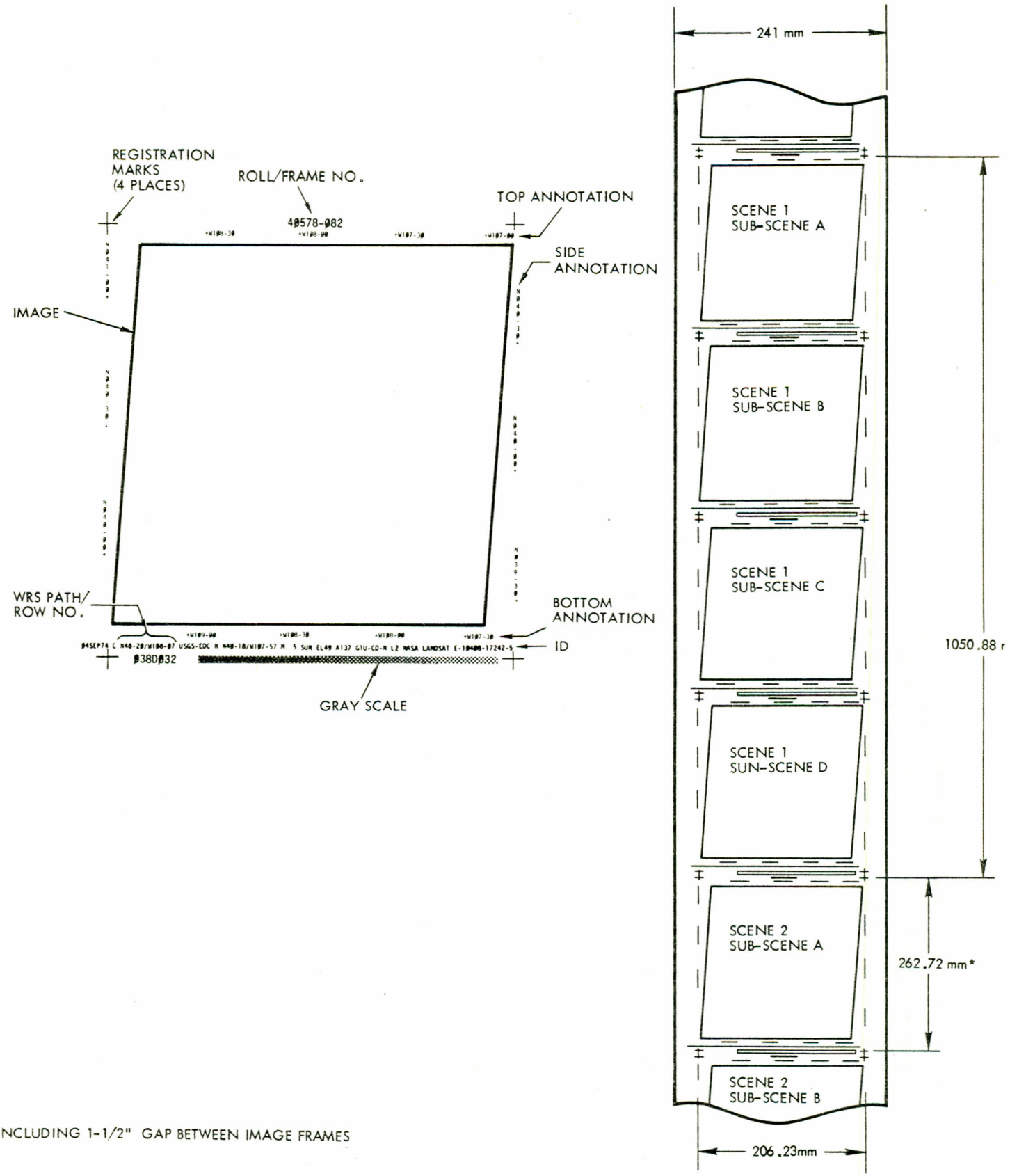
Line Nos.	Description	Total No. of Lines	Type
1-505	Top "Gap" Lines	505	B
506-529	Filler Lines	24	B
530-706	Top Fiducial Marks, Roll/Frame No. (see Note 1)	177	B
707-735	Filler Lines	29	B
736-782	Top Annotation/Tick Marks (see Note 3)	47	B
783-785	Filler Lines	3	B
786-6107	Ground Image, "One's" Fill	5322	A
6108-6110	Filler Lines	3	B
6111-6157	Bottom Annotation/Tick Marks (see Note 3)	47	B
6158-6172	Filler Lines	15	B
6173-6219	ID	47	B
6220-6234	Filler Lines	15	B
6235-6411	Bottom Fiducial Marks, Path/Row No. (see Note 2), Gray Scale	177	B
6412-6916	Bottom "Gap" Lines	505	B

NOTES:

1. Roll/Frame No.: Line nos. 530-670 (141 total lines).
2. Path/Row No.: Line nos. 6271-6411 (141 total lines), except that the "A", "B", "C", or "D" designations are lines 6318-6364 (47 total lines).
3. Tick Marks: Occupy the center 31 lines.

Table 5-5. HRFR Film, RBV Line Formats

Byte Nos.	Description	Total No. of Bytes
TYPE A - TYPICAL IMAGE LINE		
1-10	Filler Bytes	10
11-41	Left Side Annotation/ Tick Marks	31
42-52	Filler Bytes	11
53-5374	Ground Image, "One's" Fill Bytes	5322
5375-5385	Filler Bytes	11
5386-5416	Right Side Annotation/ Tick Marks	31
5417-5428	Filler Bytes	12
TYPE B - TYPICAL ANNOTATION LINE		
1-177	Left Fiducial Mark or Filler Bytes	177
178-5251	Filler Bytes and Roll/ Frame No., or Path/Row No. and Gray Scale, or ID, or Filler Lines	5074
5252-5428	Right Fiducial Mark or Filler Bytes	177



* INCLUDING 1-1/2" GAP BETWEEN IMAGE FRAMES

Figure 5-16. LANDSAT C Sub-Scene RBV (for 1:500,000 scale) Typical Film Recording

5-15. ANNOTATION DATA

Each annotation major frame contains both the alphanumeric information printed at the bottom of a film product and the tick mark information that surrounds the fully processed framed image for a specific map projection. Figure 5-14 illustrates the relationship of both the annotation and the tick mark information relative to the fully processed image writing area independent of map projection. Each minor frame begins with the standard six bytes of sync pattern, minor frame count, and minor frame type code. This is followed by a variable number of bytes of annotation data. The remainder of each minor frame is zero-filled. The last minor frame in the major frame is completed with a field of zero filler. An example of a major frame of annotation is shown in Figure 5-17 for MSS data, and in Figure 5-18 for RBV data.

The first minor frame of annotation data contains the 115 bytes of annotation data that is printed at the bottom of a film product and is fully illustrated in Figure 5-19 and described in Table 5-6. The data content of the next six minor frames is limited to the tick marks that surround the full processed image. The format of each of these next six annotation minor frames is given in Figure 5-17. Figure 5-20 illustrates tick mark features and their proper utilization in a fully processed (i.e., geometrically corrected) image. Pixel 1, scanline 1 in the fully processed image is the reference point from which all tick mark information is provided and each tick mark position represents a distance of 500 meters from the fully processed image area. As shown at the bottom of Figure 5-20, the most significant bit in the binary tick mark location bytes specifies the placement and format of the coordinate data. Specifically a "0" signifies either below or to the right of the tick mark with trailing blanks and a "1" signifies either above or to the left of the tick mark with leading blanks. Tick mark annotation examples for various map projections are provided in Figure 5-21.

In the annotation major frame, space has been reserved for 16, 25, 25, and 16 tick marks on the top, left, right and bottom sides respectively. Of these total possible tick marks for this application, up to ten tick marks on each of the four sides are provided in minor frames one, two, four, and six. Within each of these minor frames the tick mark data are left justified (with respect to the minor frame), and all unused data fields remaining are zero filled. The concluding minor frames (number seven through eleven) are zero filled. The order of tick mark data (both in appearance in the respective minor frame and on the image product) is summarized below:

Tick Mark Zone	Order of Appearance
Top	Left to right
Left	Top to bottom
Right	Top to bottom
Bottom	Left to right

30400-6009-RU-00

3232 bits

Minor Frame	48 bits: 32 bits	8 bits	8 bits	(3184 Bits) (398 Bytes)	
0	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Annotation Line Data (115 bytes)	Zero Fill (283 bytes)
1	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Top Edge Tick Mark Data 16 Coordinates (9 bytes ea.) (144 bytes)	Zero Fill (254 bytes)
2	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Left Side Tick Mark Data, First 18 Coordinates (9 bytes ea.) (162 bytes)	Zero Fill (236 bytes)
3	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Left Side Tick Mark Data, Concluding 7 Coordinates (9 bytes ea.) (63 bytes)	Zero Fill 335 bytes)
4	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Right Side Tick Mark Data, First 18 Coordinates (9 bytes ea.) (162 bytes)	Zero Fill (236 bytes)
5	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Right Side Tick Mark Data, Concluding 7 Coordinates (9 bytes ea.) (63 bytes)	Zero Fill 335 bytes)
6	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Bottom Edge Tick Mark Data 16 Coordinates (9 bytes ea.) (144 bytes)	Zero Fill (254 bytes)
7	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill (398 bytes)	

Figure 5-17. One Major Frame of MSS Annotation

Minor Frame	32 bits	8 bits	8 bits	(3184 Bits) (398 Bytes)	
	48 bits			3232 bits	
0	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Annotation Line Data (115 bytes)	Zero Fill (283 bytes)
1	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Top Edge Tick Mark Data 16 Coordinates (9 bytes ea.) (144 bytes)	Zero Fill (254 bytes)
2	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Left Side Tick Mark Data, First 18 Coordinates (9 bytes ea.) (162 bytes)	Zero Fill (236 bytes)
3	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Left Side Tick Mark Data, Concluding 7 Coordinates (9 bytes ea.) (63 bytes)	Zero Fill 335 bytes)
4	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Right Side Tick Mark Data, First 18 Coordinates (9 bytes ea.) (162 bytes)	Zero Fill (236 bytes)
5	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Right Side Tick Mark Data, Concluding 7 Coordinates (9 bytes ea.) (63 bytes)	Zero Fill 335 bytes)
6	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Bottom Edge Tick Mark Data 16 Coordinates (9 bytes ea.) (144 bytes)	Zero Fill (254 bytes)
7	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill (398 bytes)	
8	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill (398 bytes)	
9	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill (398 bytes)	
10	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill (398 bytes)	
11	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill (398 bytes)	

Figure 5-18. One Major Frame of RBV Annotation

DATA FIELD:	a	b	c	d	e	f	g	h	i
CHARACTER POSITION:	12345678	1111111111222222 90123456789012345	222233333 678901234	33333444444444455 56789012345678901	5555555566 2345678901	66666666777777 23456789012345	777788888888 678901234567	1 8899999999990 8901234567890	111111111111111 000000000111111 123456789012345
EXAMPLE:	07JUN76	C N33-05/W115-18	0202-101	N N33-03/W115-42	M 4 D	SUN EL30 A015	U1L-CD-N L2	NASA LANDSAT	E-11042-16032-4
OTHER POSSIBLE DATA ELEMENTS:			A		5 6 7 8 R A 1B 2C 3D		U1L-CP MB111 S2P ND A0L2 G3S 1 R U 2		5 6 7 8 1 2 3 A B C D
SEE TABLE 5-6 FOR FULL EXPLANATION									

Figure 5-19. The 115-Character Annotation Field

Table 5-6. Detailed Explanation of 115-Character Annotation Field

Field	Character Position	Example	Explanation
a	01-08	07 JUN 76	Day, month and year of picture exposure.
b	09-25	C N33-05/W115-18	Format Center -Latitude and longitude at the center of the RBV and MSS image format are indicated in degrees and minutes. RBV image center is defined at scanline 2662, pixel number 2662. MSS image center is defined at scan line 1492, pixel number 1774.
c	26-34	D202-101	The "D" indicates spacecraft is descending, an "A" indicates spacecraft is ascending. Nominal path and row identifier. The 202 is path number and 101 is row number.
d	35-51	N N33-03/W115-42	Nominal latitude and longitude.
e	52-61		Characters in this group are sensor and spectral band specific: For RBV images:
	52-56		Sensor spectral band identification code.
	57-58		RBV Shutter Duration Code, the "XA" refers to shutter speed.

Table 5-6. Detailed Explanation of 115-Character Annotation Field (Continued)

Field	Character Position	Example	Explanation
	59		Aperture Correction Indicator I - Aperture correction "in" O - Aperture correction "out" - blank
	60		"D" indicates direct transmission. "R" indicates stored data played back from the satellite WBVT recorder.
	61		Blank
			<u>For MSS images</u>:
	52-58		The sensor spectral band identification code.
	59		Blank
	60		"D" indicates direct transmission. "R" indicates stored data played back from the satellite WBVT recorder.
	61		Blank
f	62-75	SUN EL30 A015	Sun Angles - the sun elevation angle and sun azimuth angle measured clockwise from true North at the time of RBV exposure or midpoint of MSS frame is specified to the nearest degree. Blank for ascending node coverage.

Table 5-6. Detailed Explanation of 115-Character Annotation Field (Continued)

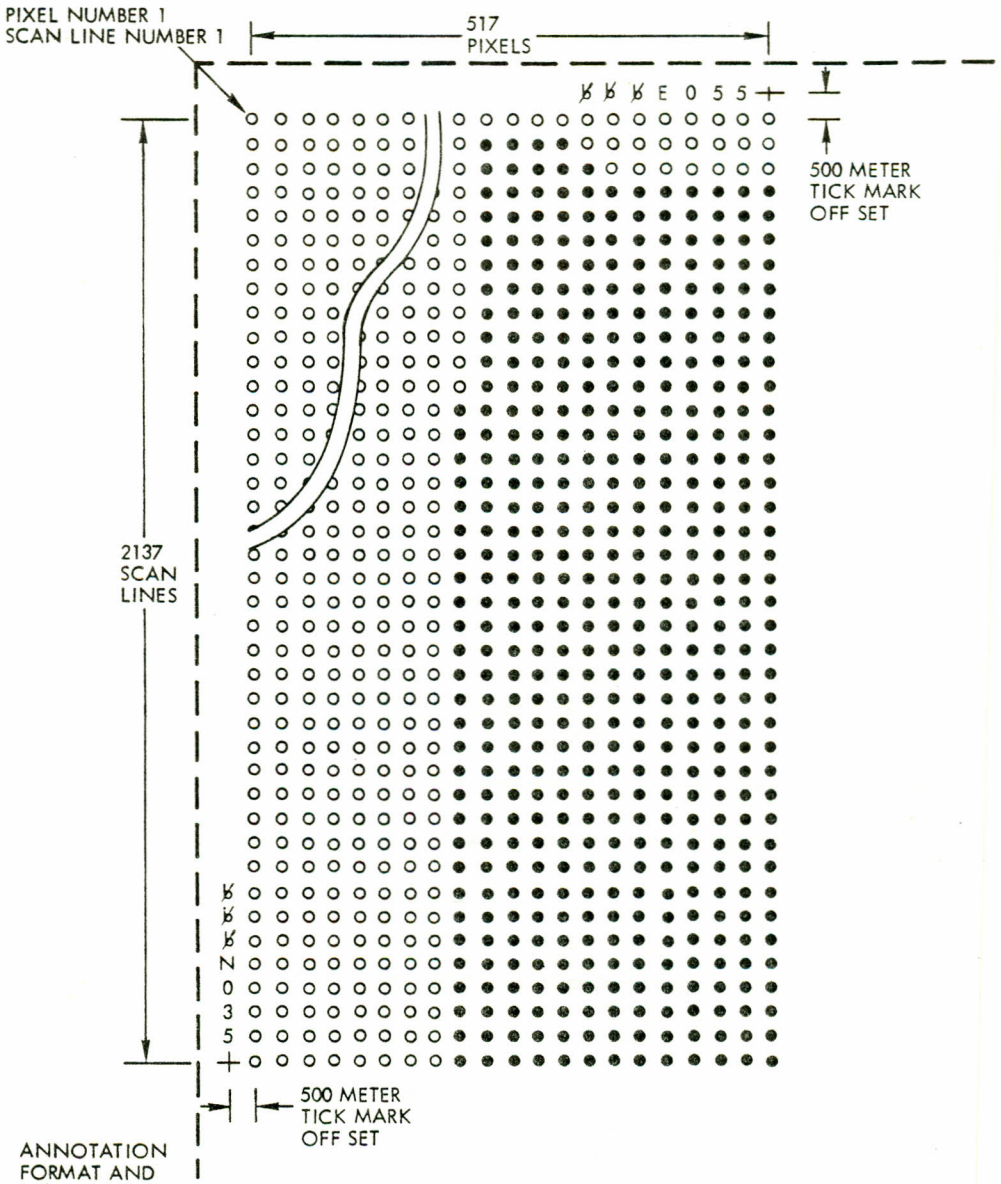
Field	Character Position	Example	Explanation
g	76-87	U1L-CD-N L2	
	76		Character position 76 defines the type of geometric correction applied to the data: "U" = uncorrected "S" = system level "G" = geometrically corrected based on geometric GOP's "R" = geometrically corrected based on relative GOP's
	77		Character position 77 indicates the scale of the image: "1" = 185 km. x 185 km. "2" = 98 km. x 98 km. (RBV) "3" - 185 km. x 170 km. (MSS)
	78		Character position 78 defines the projection: "L" = Lambert projection "P" = Polar Stereo projection "S" = Space Oblique Mercator projection "U" = Universal Transverse Mercator projection
	80		Character position 80 indicates the resampling algorithm: "C" = cubic "N" = nearest neighbor

Table 5-6. Detailed Explanation of 115-Character Annotation Field (Continued)

Field	Character Position	Example	Explanation
	81		Character position 81 indicates the type of ephemeris data used to compute the image center: "P" = predictive "D" = definitive (for system level correction only)
	83		Character position 83 gives the processing procedure: "N" = normal processing procedure. "A" = abnormal processing procedure.
	84		Character position 84 defines whether an earth image or whether an RBV calibration image has been processed: blank = earth image Either "0", "1", or "2" = RBV Radiometric calibration images, indicating lowest to highest exposure level respectively.
	85		Character position 85 indicates the sensor gain options: "H" = high gain "L" = low gain
	86		Character position 86 shows the type of MSS transmission: "1" = linear mode "2" = compressed mode.

Table 5-6. Detailed Explanation of 115-Character Annotation Field (Continued)

Field	Character Position	Example	Explanation
h	88-100	NASA LANDSAT	Identifies the Agency and the Project.
i	101-115	E-11042-16032-4	Frame identification number -- each image or frame will have a unique identifier which will contain encoded information consisting primarily of time of exposure relative to launch. Its format is E-ADDDD-HHMMS-B and is interpreted as follows: "E" - Encoded Project Identifier A - Landsat Mission: 1 - Landsat 1 2 - Landsat 2 3 - Landsat 3 DDDD - Day number, relative to launch, at time of observation HH - Hour at time of observation MM - Minute at time of observation S - Tens of seconds at time of observation B - IPF identification code (RBV A, B, C, D; MSS 4, 5, 6, 7, 8; RBV 1, 2, 3)



TOP	10000010	00000101	Ø	Ø	Ø	E	0	5	5
SIDE	10001000	01011001	Ø	Ø	Ø	N	0	3	5

* WHEN MSB= 1, ANNOTATION IS ABOVE OR TO THE LEFT OF TICK MARK WITH LEADING BLANKS.
* WHEN MSB= 0, ANNOTATION IS BELOW OR TO THE RIGHT OF TICK MARK WITH TRAILING BLANKS.

Figure 5-20. Placement of Tick Mark Coordinates and Corresponding Annotation with Respect to Fully Processed Image Data

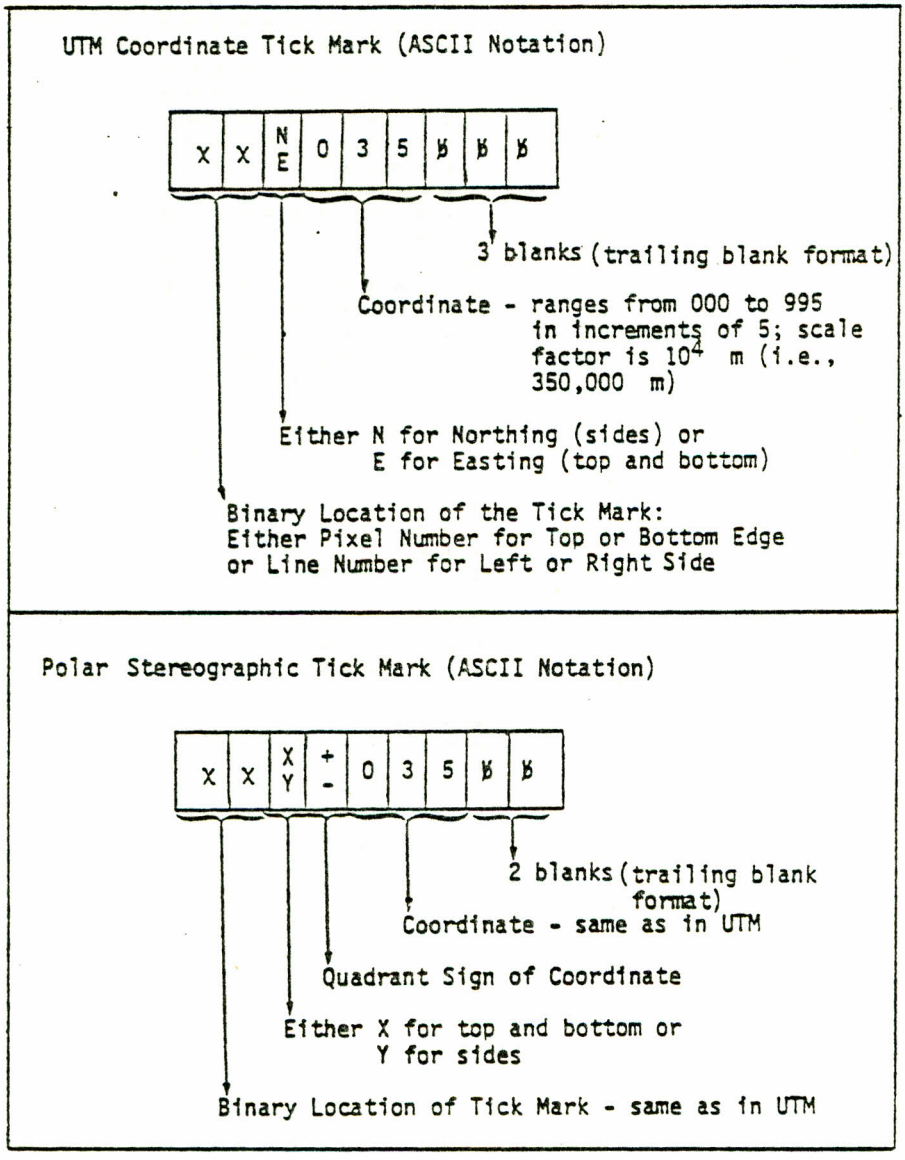


Figure 5-21. Tick Mark Annotation

5-16. IMAGE ENHANCEMENT ALGORITHMS

EDIPS employs three image enhancement algorithms: Contrast Stretch, Haze Removal, and High Frequency Edge Enhancement. The first two utilize histogram transformations to adjust the overall and specific characteristics of input image data. The third, High Frequency Edge Enhancement, uses a spatial (box) filter to boost high-frequency spatial contact within the image. Edge enhancement is performed in the special order processing mode only.

5-17. CONTRAST STRETCH

Associated with each MSS band or RBV subscene processed by EDIPS is a unique histogram of pixel-by-pixel radiance values. The Contrast Stretch algorithm magnifies the subtle variations in brightness contained in the original digital image and distributed in the histogram. A linear stretch is generated by mapping each grey level encountered in the image, pixel-by-pixel, and then separating (stretching) the pixel grey levels as much as possible to fill the complete dynamic range of the display medium.

The contrast stretch algorithm is defined as follows:

$$Y_{ij} = \left(\frac{X_{ij} - Min}{Max - Min}\right) \times C \qquad (1)$$

where

X_{ij} = Input pixel value at line i and sample j

Y_{ij} = Corresponding output pixel value at location (i,j) after the Contrast Stretch

[Min,Max], a subset of [0,255], representing the range of Min-Max brightness of a particular scene

C = Nominal value of 127

a. Determination of Min-Max Levels

It is critical that the Min-Max levels be properly determined. Improper designation of [Min,Max] values may degrade the image information content and create imagery which has a distorted histogram relationship. The following algorithm is designed to automatically determine the Min-Max levels for each spectral band or RBV subscenes based upon a user-supplied value of percent grey level of the histogram LHTV and RHTV, as specified on the WOC.

Let bin (1), bin (2),..., represent the histogram pixel counts for bin 1, bin 2,...., etc; and let dist (n,m) represent the absolute distance in grey level between bin #n and bin #m. Assume that the constant C equals 255.

Min Level Determination

Step 0: Compare bin (1) against a predetermined left-hand threshhold value (LHTV); if bin (1) $\geq$ LHTV, then Min = 0.
Otherwise, n=1 go to step 1.
For iteration number n = 1,2,3,---

Step 1: If bin (n) + bin (n+1) $\geq$ LHTV, then
Min = dist (1,n) + 0.5 * dist (n,n+1)
Otherwise step 2

Step 2: Lump bin #n and bin #n+1 into one bin by adding bin (n) to bin (n+1). The new bin location becomes dist (1,n+1). After lumping two bins, increase the iteration number by one and repeat the steps 1 to 2.

Max Level Determination

Step 0: Compare the last bin count (e.g., bin (255)) against right-hand threshold value (RHTV); if bin (255) $\geq$ RHTV, then Max = 255, otherwise n=1; - go to step 1. For iteration number n=1,2,3,---

Step 1: If bin (255-n) + bin (255-n+1) $\geq$ RHTV,
Max = dist (1,255-n) + 0.5*dist (255-n, 255-n+1)
Otherwise go to step 2.

Step 2: Lump two bins into one new bin by adding bin (255-n+1) to bin (255-n). The corresponding new bin center becomes dist (1,255-n).
After lumping two bins, increase the iteration number by one and repeat the steps 1 to 2.

A possible set of threshold values are:

LHTV = 2% of the total pixel counts per each spectral band or RBV subscene

RHTV = 3% of the total pixel counts per each spectral band or RBV subscene

As an alternative, the user may specify specific grey values for the Min-Max levels on the WOC.

After the determination of Min-Max levels, the mapping from input image to the contrast adjusted output image is thus defined via Equation (1). A table lookup scheme, which uses the input pixel values (Max. 255 discrete levels) as the table address and the corresponding table entry containing the computed output pixel value, is employed to speed up the contrast adjustment process.

b. Automatic Histogram Cutoff

An Automatic Histogram Cutoff ("Spike Tail Cutoff") has been developed for pipeline processing and applies to both Contrast Stretch and Haze Removal. This algorighm looks for further histogram information to select the optimal cutoff points (i.e., the Min-Max levels) to construct the radiance adjustment table. It is described as follows:

Definition 1. Let F be a real function that represents the histogram of a band and F(t) is the frequency at grey level t. If $F(t_o) \geq P$, then there is a spike at t_o. (P is a constant which is determined by the users.)

Definition 2. Let S be a set of integers and min(S) and max(S) denote the minimum and maximum in S respectively.

Definition 3. Let W, X, Y, Z be real numbers stored in the data base. W and Y are the percentages which are used to determine the lower W% and the upper Y% cutoff points. X and Z are the percentages which are used to determine the minimum spike size on both ends of the histogram.

THE ALGORITHM

1) Read W, X, Y, Z from data base.

2) Set P = x/100 x (the number of pixels in a band).

3) Set a = the W% cutoff point at lower end.

4) Let $S = \{t \mid t \text{ is integer}, 0 \leq t \leq 255 \text{ and } F(t) \geq P\}$, $t_i = \min(S)$ and $A = \{t \in s \mid t - t_1 \leq 3\}$.

   Then, consider all the spikes in A are grouped together as the first spike group. It starts at t_1 and ends at max(A).

5) Let $t_2 = \min(S \backslash A)$. Then t_2 is the starting position of second spike group.

6) Let $b = \max(A) + t_2/2$

7) Lower cutoff point = min(a,b)

8) Set P = Z/100 x (the number of pixels in band)

9) Set c = the Y% cutoff point at upper end.

10) Let $S = \{t \mid t \text{ is integer}, 0 \leq t \leq 255 \text{ and } F(t) \geq P\}$, $t_3 = \max(S)$ and $B = \{t \in s \mid t_3 - t \leq 3\}$

Then, consider all the spikes in B are grouped together as the last spike group. It starts at min(B) and ends at t_3.

11) Let $t_4 = \max(S \backslash B)$. Then t_4 is the ending position of the next to last spike group.

12) Let $d = \min(B) + t_4/2$

13) The upper cutoff point = max(c,d)

5-18. HAZE REMOVAL

EDIPS can correct image data for atmospheric scattering ("haze"). An offset grey level is established for each spectral band. The offset is the amount of haze in the band it is subtracted from each pixel value. Thus, the Haze Removal algorithm is defined as follows:

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

where

X_{ij} = Input pixel value at line i and sample j

Y_{ij} = Enhanced pixel value at same location (i,j)

Bias is the amount of offset for each spectral band (i.e., Bias = Min). The bias is specified on the WOC by the user for special orders.

5-19. HIGH FREQUENCY EDGE ENHANCEMENT

EDIPS performs high frequency edge enhancement to improve the visibility of fine structure in an image. The object of this enhancement process is to boost the proportional contribution of high frequency spatial variation in the

final image. The high frequency components are first extracted from the image, and then added back to the original image. The algorithm is defined as follows:

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

where

X_{ij} = Input (original) pixel value at line i and sample j

Y_{ij} = Output (enhanced) pixel value at line i and sample j

C = A constant which controls the amount of enhancement

$\overline{X}_{ij}$ = A local average value at location (i,j) obtained by using a box filter, according to

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

X_{Pr} is for a box filter of size M (line) x N (pixels). The range of N and M is between one and nine, and is odd (i.e., 1, 3, 5, 7, and 9).

APPENDIX

EDIPS SOFTWARE MODULES

APPENDIX

EDIPS SOFTWARE MODULES

A-1. SOFTWARE MODULE FUNCTIONS

The functions of the individual software modules are summarized in Table A-1. For ease of access, the modules are listed in alphabetical order. The SEL-supplied and FPS-supplied modules are not included in the table. For additional information on those modules, refer to the SEL and/or FPS reference manuals.

Table A-1. EDIPS Software Module Functions

Module	Functions
APHFE	Special order module executed in the AP-120B under control of module IPHFE: 1. Reads imagery from SEL memory 2. Stores each pixel in AP floating point notation 3. Constructs radiance adjustment tables from data supplied by IPHFE 4. Performs high-frequency edge enhancement using variable size low-pass filter, not to exceed 9 x 9 pixels 5. Converts pixels from AP floating point notation to SEL notation, one byte per pixel format 6. Transfers image data to SEL memory 7. Performs pixel-by-pixel radiance adjustment.
DBASE	1. Determines input device (card reader or CRT) for the following cases: a. When both input devices are available b. When only the CRT is available c. When only the card reader is available. 2. Outputs message to OC specifying input device (if any)

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
DBASE (Cont)	3. Outputs termination message to OC (via LOGGEN) and terminates if module SCHED is active when DBASE is activated 4. Allocates and opens input and output files 5. Deallocates and closes input and output files 6. Outputs interactive prompts to the CRT when the CRT is the input device 7. Reads DBASE inputs through the card reader 8. Reads DBASE inputs through the CRT 9. Validates DBASE directive inputs 10. Validates format of DBASE parameter modification inputs 11. Validates modifications to data base parameters 12. Outputs an input error message to the line printer (if available), on detection of input errors from card reader input, lists the cards with errors on the line printer, outputs termination message to OC (via LOGGEN), and terminates 13. Outputs an input error message to the CRT on detection of input errors from CRT input, lists the lines with errors on the CRT and requests user to enter next directive 14. Performs the following functions under operator-specified directives: a. Restores static data base parameters residing on the data base disk file into GLOBALOO b. Saves the static data base parameters residing in GLOBALOO on the data base disk file

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
DBASE (Cont)	c. Outputs a hard copy of the static data base parameters in Global Common on the line printer d. Modifies static data base parameters in GLOBALOO. 15. Sends message to OC (via LOGGEN) when the line printer is not available and DBASE requires the line printer for output 16. Outputs the static data base parameters to the processing log after each restore of the static data base from disk 17. Outputs modified data base parameters to the processing log 18. Outputs termination message to OC (via LOGGEN) and terminates when both card reader and the CRT are unavailable 19. Outputs error message to OC (via LOGGEN) and terminates when an RTM abort occurs 20. Checks for maximum number of modification lines/cards for each modification directive 21. Verifies CS minimum/maximum parameters are consistent with CS units 22. Preserves the date and time when the data base was last modified 23. Does not update data base parameters with invalid modifications.
DEVSET	1. Allows the device status for selected devices in the EDIPS configuration matrix to be put into either a ready-for-use or not-ready-for-use status 2. Outputs to both the processing log and the Operator Console a message regarding the operational configuration.

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
DSKVFY	1. Activates upon request from operator's console 2. Interprets operator's request as to specific disk to verify and/or termination request 3. Determines the availability status of the requested disk. If unavailable, rejects the disk verification procedure 4. Allocates multiple buffers for the data transfers from and to the disk 5. Presets the write-sealed-cylinder-table 6. Sets each word of an internal image block buffer to a predefined constant 7. Transfers the internal image block buffer to every image block within a cylinder 8. Determines the status associated with each internal image block data transfer to the disk 9. In the write-sealed-cylinder-table, designates as unacceptable any cylinder exhibiting an unfavorable status for any data transfer to the blocks within the cylinder 10. Rejects the disk whenever the number of unacceptable cylinders defined within the write-sealed-cylinder-table exceeds a predefined acceptable maximum 11. Presets the read-sealed-cylinder-table 12. Transfers every image block of a cylinder to one of the multiple internal image block buffers 13. Determines the status associated with each image block transferred from disk to the internal image buffer

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
DSKVFY (Cont)	14. In the read-sealed-cylinder-table, designates as unacceptable any cylinder exhibiting an unfavorable status for any image block transferred from the disk to the internal image buffer 15. In the read-sealed-cylinder-table, designates as unacceptable any cylinder producing any data difference between the data contents of the internal image buffer transferred to disk and the data contents of the internal image buffer transferred from the disk 16. Rejects the disk whenever the number of unacceptable cylinders defined within the read-sealed-cylinder table exceeds a predefined acceptable maximum 17. Merges the write-sealed-cylinder-table and the read-sealed-cylinder-table to create the composite sealed-cylinder-table 18. Rejects the disk whenever the number of unacceptable cylinders defined within the composite sealed-cylinder-table exceeds a predefined maximum 19. Rejects the disk whenever the number of contiguous unacceptable cylinders indicated in the composite sealed-cylinder-table exceeds a predefined maximum 20. Determines whether the cylinder that will contain the sealed-cylinder-table has been designated as being unacceptable. If unacceptable, rejects the disk 21. Transfers the composite sealed-cylinder-table to the disk 22. Determines the status associated with the sealed-cylinder-table transfer to the disk 23. Rejects the disk whenever the status returned from the sealed-cylinder-table transfer to the disk is unacceptable

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
DSKVFY (Cont)	24. Reads the sealed-cylinder-table from the disk and verifies the contents 25. Rejects the disk whenever the verification process indicates a data inconsistency 26. Transfers the composite sealed-cylinder-table to the SLO file for subsequent transfer to the line printer, as follows: a. Reads every cylinder on each mounted disk pack and detects any errors incurred during such reads b. Creates a table marking any cylinder containing an unreadable sector as unreadable c. Writes the unreadable cylinder table the disk pack just verified d. Displays to the operator how many cylinders on each disk pack have been marked as unreadable e. Rejects a disk pack as unacceptable to the EDIPS processing due to lack of enough readable cylinders.
FILMCH	1. Prompts the operator for roll/frame number 2. Prompts the operator for TIFT replacement 3. Outputs the roll/frame number and TIFT information to the LOGFILE.
GLOBALOO	Provides a common storage area for all EDIPS modules. Contains the variables, their definition, and the constants used in common by the EDIPS modules. Consists of 11 separate data buffers/files: COMDEF, WOCSET, DSKCON, HRFRCON, HDTCON, SCHEDPAR, SCENE, DBPAR, DEVSTAT, LOGSUM, and INANNCCT.
HDTRONL	1. Determines that the HDTR is operational 2. Operates the HDTR in a predefined order

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
HDTRONL (Cont)	3. Outputs messages relating to failure conditions 4. Contains three major subprograms: a. Program HDTRONL1 tests the ability of the HCS to transfer and hold data, and tests the functional aspects of the HCS. Every bit of every cell is tested to hold data correctly b. Program HDTRONL2 tests data transfer and storage capability of that portion of each SCI that can be accessed by the HCS c. Program HDTRONL3 sequences the system through a process that is typical of normal use. Overlapped tape searches, pixel data transfers, histogramming enabled and disabled are included in the test.
HFFTN	HFFTN interfaces to driver S.HFOO under the following requirements: 1. Callable from FORTRAN or MACRO 2. Converts its received parameters into the proper format for calling module S.HFOO 3. Supports all functions of the TCS handler 4. Passes to its initiator all status conditions made available by the TCS handler 5. Supports command chaining 6. Supports data chaining 7. Returns control to its caller after initiating the requested function 8. Suspends itself until the currently active function has completed 9. Supports error recovery.

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
HRFRONL	1. Determines that the HRFR is operational 2. Operates the HRFR in a predefined order 3. Outputs messages relating to failure conditions 4. Contains three major subprograms: a. Program HRFRONL1 tests the ability of the TCS to transfer and hold data, and tests the functional aspects of the TCS. Every bit of every cell is tested to hold data correctly b. Program HRFRONL2 tests data transfer and storage capability of that portion of the HRFR that can be accessed by the TCS c. Program HRFRONL3 sequences the system through a process that is typical of normal use. Pixel data transfers, table look-up enabled and disabled are included in the test.
HTFTN	HTFTN interfaces to driver S.HTOO under the following requirements: 1. Callable from FORTRAN or MACRO 2. Converts its received parameters into the proper format for calling module S.HTOO 3. Supports all functions of the HCS handler 4. Passes to its initiator all status conditions made available by the HCS handler 5. Supports command chaining 6. Supports data chaining 7. Returns control to its caller after initiating the request function

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
HTFTN (Cont)	8. Suspends itself until the currently active function has completed 9. Supports error recovery.
IDFTN	IDFTN interfaces to driver S.IDOO under the following requirements: 1. Callable from FORTRAN or MACRO 2. Converts its received parameters into the proper format for calling module S.IDOO 3. Maps user requests in such a manner as to avoid areas on the disk flagged as unreadable 4. Passes to its initiator all status conditions made available by S.IDOO 5. Returns control to its caller after initiating the requested function 6. Suspends itself until the currently active function is complete 7. Supports error recovery 8. Provides dynamic cylinder sealing 9. Accesses annotation and image areas.
INCCT	1. Controls the processing of Type A CCT's for corrected data 2. Transfers requested bands or subscenes of image data from Landsat 1, 2, and C CCT's to disk file 3. Verifies scene ID 4. Provides operator communication 5. Provides device error recognition and handling 6. Informs scheduler of disk unit used.

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
INHDT	1. Reads HDT_A or HDT_P data 2. Transfers non-image data to core buffers 3. Transfers image and ancillary data to 80MB disk 4. Compiles and summarizes: a. Image data quality b. Left/right fill count. 5. Transfers histogram to scene buffer 6. Processes all images/scenes specified on the WO 7. Provides the scheduler with status: a. Image complete b. Scene complete c. WO complete. 8. Recognizes and responds to: a. Disk write errors b. SCI/HCS/HDTR errors c. Data processing anomalies.
INMOUNT	1. Checks availability of the HCS/HDTR/SCI via the device status array. Allocates HDTR if available; aborts search if not 2. Notifies operator to mount tape on designated unit 3. After operator continue indication, moves tape forward until 5 distinct IRIG seconds are read. If this takes more than 500 feet of tape, aborts WO 4. In the event of a hardware/tape/mount failure, aborts the WO and takes the HDTR/SCI off line 5. Sends appropriate error and status messages to the operator's console and/or log file 6. Rewinds HDT in the event of a mount abort.

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
INSRCH	1. Processes two Work Orders (WOs) concurrently (two SCI/HDTRs) 2. Initiates IRIG-A time code search for both WOs 3. Polls HCS until: a. Search completion on one WO b. Occurrence of an error c. Additional WO available for processing. 4. Informs scheduler of processing status: a. Search completed for WO b. Abort WO.
IPHFE	Special order module controlling the performance of high-frequency edge enhancement: 1. Receives control information from SCHED including: a. Sensor type (MSS or RBV) b. Scene ID c. Band(s)/subscene to process d. Available image disk e. Filter specification f. Radiance adjustment request 2. Accesses radiance adjustment tables 3. Inputs logical blocks of image data from the image disks 4. Transfers image data to the AP-120B 5. Transfers radiance adjustment data to the AP-120B table memory (to perform contrast stretch/haze removal adjustments, if required) 6. Receives enhanced image data from the AP-120B

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
IPHFE (Cont)	7. Controls the AP-120B to perform image enhancement algorithms 8. Processes errors from the image disks and the AP-120B 9. Generates processing status information for the processing log, including process initiation and termination 10. Provides the SCHED processing status information 11. Transfers enhanced imagery from the AP-120B to SEL memory 12. Transfers imagery from SEL memory to image disk.
IPRAC	1. Calculates table look-up values for haze removal and contrast stretch 2. Calculates histogram mean and standard deviation 3. Creates a radiance mapping table for: a. PGFILM (Hardware) b. PGDIGI (Software) c. APHFE (Firmware). 4. Generates hardcopy histogram output if required on WO or if CCT product is being generated.
LOG	1. Displays the status messages in the LOGFILE 2. Generates hardcopy of the LOGFILE on the line printer 3. Displays a specified time of a day. (To allow the operator to review messages output at earlier times.) 4. Purges the LOGFILE 5. Prints a hardcopy and display summary information based upon tagged code outputs from the modules

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
LOG (Cont)	6. Displays/prints only selected entries in the LOGFILE based on priority codes
	7. Copies the LOGFILE to tape.
LOGGEN	1. Transfers messages generated by the various software modules to the processing log (LOGFILE). Appends the time to the message
	2. Outputs data to the operator indicating time and cause for each fatal transmission error
	3. Transfers error messages generated by the various software modules to the operator's console.
MRTM	1. Allows for the specification of 80 MB disks as not being part of the operational system
	2. Allows for use of 115 sector allocation units when selecting the 80 MB disks
	3. Allows for the use of statistical error monitoring of all EDIPS peripherals
	4. Allows for the deletion of mount messages for resident EDIPS modules
	5. Allows for the date to be updated at midnight crossover.
PGDIGI	1. Creates a CCT output from HDT input: a. "A" format output only b. MSS input BSQ - output BSQ, BIL c. RBV input SSQ - output SSQ.
	2. Performs table look-up for haze removal/contrast stretch
	3. Writes TIFT record to tape
	4. Provides hardcopy of CCT processing printout.

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
PGFILM	1. Reads image data from 80 MB disk 2. Reads side, top/bottom annotation data from 80 MB disk 3. Rasterizes roll/frame number 4. Rasterizes band number for MSS 5. Controls TCS/HRFR table look-up 6. Provides for initialization and film change through low film and modulator bias limit warning 7. For MSS bands selected: a. Transfers radiance mapping table to HCS b. Puts roll/frame in TIFT file c. Writes film gap d. Performs image transfer e. Writes film gap and TIFT.
PGRAST	1. Initializes internal constants and creates a template 2. Rasterizes top and bottom tick mark annotation, left and right tick marks, bottom ID annotation, and path/row number 3 x size.
PGTIFT	1. Creates the Transient Image File Tape (TIFT) record - 1 TIFT record per MSS band/RBV subscene processed 2. Obtains TIFT data from scene buffer, INHDT program and IPRAC program.
S.HFOO	1. Controls the TCS under at least the following functions, as specified by the applications software: a. Places HRFR in standby mode b. Places HRFR in ready mode c. Writes to HRFR d. Checks HRFR status e. Selects RBV or MSS mode f. Loads TCS table g. Loads TCS control parameters h. Places HRFR in record mode.

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
S.HFOO (Cont)	2. Detects and reports at least the following status conditions: a. Data late error (buffer underflow) b. Low film warning c. HRFR master fault warning d. HRFR calibration required. 3. Services completion interrupts from the TCS by the standard RTM method 4. Services error interrupts from the TCS by the standard RTM method 5. Supports command chaining 6. Supports data chaining.
S. HTOO	The OSS controls and monitors the HCS and, through the HCS, two SCIIs, one SCIO, and two HDTRs under the following requirements for module S.HTOO as limited by the controller 1. Controls the HDTR/HCS under at least the following functions, as specified by the applications software: a. Searches to specified bit b. Reads/Writes all SCI and HCS registers c. Starts/Stops tape motion d. Reads/Writes major frame e. Rewinds HDT f. Reads and clears current histogram g. Specifies input subsets to be histogrammed. 2. Controls one HDTR in the search mode while transferring data from another 3. Detects and reports at least the following status conditions: a. Transfer complete b. Parity error(s) detected c. Synchronization lost d. Hardware buffer overflow e. End of tape detected f. Search complete.

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
S.HTOO (Cont)	4. Services completion interrupts from the HDTR by the standard RTM method 5. Services error interrupts by one or both of the following, depending on the error: a. Attempt recovery b. Inform I/O initiating task of the condition. 6. Supports command chaining 7. Supports data chaining 8. Controls two HDTRs in search mode simultaneously.
S.IDOO	The OSS controls and monitors the five 80 MB image disks through three 9010 controllers under the following requirements for module S.IDOO (as limited by controller constraints): 1. Controls the image disks under at least the following functions, as specified by the applications software: a. Seeks a cylinder b. Reads/Writes a specified number of words starting at a specified section. 2. Detects and reports at least the following status conditions: a. Seek error b. Parity error. 3. Services completion interrupts from the image disk in any of the following ways: a. Starts next transfer and report to I/O issuing routine b. Reports to I/O issuing routine. 4. Services error interrupts in one of the following ways: a. Attempts recovery b. Requirements deleted c. Aborts transfer, reports error, returns to I/O issuing routine.

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
SCHACT	1. Passes operating parameters from the various EDIPS modules to global common. The parameters include: a. Task numbers of the returning user b. The index to the proper WOC buffer entry c. Designation for the output disk d. Termination code. 2. Causes the scheduler to be resumed.
SCHED	1. Initiates processing task based on input from Work Order Card (WOC) input 2. Organizes HDT and CCT tape mount and search 3. Determines adequate processing configuration available for work order 4. Scheduler will be resumed by each user through subroutine SCHACT 5. Generates a message for the processing log every time a module is activated or terminated 6. Allocates/De-allocates disk storage 7. Provides monitor for task termination status 8. Generates output files/tables sufficient to allow for the proper selection of HDT scenes/subscenes or CCT scenes 9. Activates the following application tasks: a. Input from HDT - Search HDT input tape b. Input from CCT c. Generate TIFT d. High frequency edge enhancement e. Radiance adjustment table for contrast stretch and haze adjustment f. Rasterization of annotation g. Output to HRFR h. Output to CCT.

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
SCHED (Cont)	10. Generates error messages for immediate display to the operator and/or the processing log for all error conditions encountered 11. Performs appropriate error recovery for error conditions not processed by the applications tasks 12. Terminates all WOC processing upon operator intervention 13. Provides for special instruction prompt messages when required for any WOC 14. Allows for operator intervention only by use of the task ... STOPFLOW 15. Allows concurrent scheduling of WOCs using INHDT and INCCT subject to the following constraints: a. All WOCs must be MSS and special order b. The INHDT WOCs cannot have IPHFE or PGDIGI (i.e., they must have only film output -- PGFILM--) as part of their processing 16. Enforces the following activation constraints on INHDT WOCs (whether a concurrent INCCT WOC is scheduled or not): a. If IPHFE is not part of the ongoing WOC, does not inhibit the next WOC b. If IPHFE is part of the ongoing WOC, inhibits scheduling of any downstream tasks on the second WOC until the last task (i.e., the minus one task) is activated on the last disk of the ongoing WOC c. If either the ongoing or second WOC is RBV and the ongoing has both film (PGFILM) and CCT (PGDIGI) products, inhibits the second WOC until the last task is activated on the last disk of the ongoing WOC.

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
SCHED (Cont)	17. Ensures that tasks INCCT, IPHFE and PGDIGI are not concurrently active on the same INCCT WOC (whether or not concurrent INHDT WOC's are scheduled).
SEMS	1. Decodes device status tables 2. Initializes device status tables 3. Provides peripheral error statistics consisting of a classification and count of all errors related to all peripheral devices. This includes the following: a. Fatal errors b. Recoverable errors, listed individually c. Recovery attempts. 4. Provides statistical error monitoring whenever peripheral handlers are addressed through modification of the individual handlers 5. Provides a count of the usage of each device 6. If the line printer is unavailable, SEMS provides the capability for the statistical output to be displayed at the operator console 7. Reinitializes the handler status tables after printing out the statistics
START	1. Verifies that required hardware is present 2. Cleans and initializes specific user files 3. Displays prompt messages to operator to enter initialization information such as roll/frame number, TIFT label, etc. 4. Provides data base values to the processing log 5. Provides the disk verify information from each 80 MB disk to GLOBAL COMMON

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
START (Cont)	6. Establishes all EDIPS processing tasks in core memory
	7. Ensures that TIFT is properly mounted and positioned
	8. Activates the statistical error monitoring printout module to ensure that the flags are reset prior to EDIPS operation.
STOPFLOW	1. Allows operator to halt the processing of all WOCs when the module is activated
	2. Sends message to processing log that STOPFLOW has been activated
	3. Sets control parameters to terminate work orders in progress and discard any remaining work orders.
STSCHK	1. Enables FORTRAN programs to determine device status
	2. Callable from FORTRAN
	3. Returns to operator the status of any peripheral device accessed by FORTRAN READ and WRITE statements
	4. Returns to operator the status of any peripheral device accessed by FORTRAN BUFFER IN and BUFFER OUT statements
	5. Returns status from the following devices: 80 MB disk, CCT, Interactive CRT, Card Reader, Line Printer.
WOCPROC	1. When activated by scheduler generates a log message, checks for work orders in the TEMPWOC and if WOs are present transfer WOs from TEMPWOC to WOCFILE along with the tape-ID data
	2. Displays message on the operator's console when TEMPWOC has been emptied

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
WOCPROC (Cont)	3. When activated by the operator generates a log message, determines source of input, work orders input and validated, work orders optionally reviewed and/or printed, and processed work orders transferred to disk 4. Reads input from either the card reader or the CRT, whichever is up. If both are up, the operator is queried as to which peripheral to use. If neither the card reader nor the CRT is up, an error is logged and WOCPROC exits 5. Queries operator for the desired options -- review of the work order, and/or printout of the processed work order 6. Checks work order parameters read from the CRT for validity of entry number, entry sub-entry number, length of entry and number of entries prior to transfer into the display buffer 7. On input from the card reader, transfers fields in each card to the respective position in the display buffer. The cards must be in order (1), (1,2), (1,3), (1,2,3), or (1,3,2). An error results in termination and an error message logged 8. Validates display buffer and produces a probationary work order at the end of a modify sequence, at the termination of a work order entry on the CRT, or when a work order from card(s) has been completely entered 9. Checks display buffer for each entry being within range, consistent with other entries, and valid. Default values (when they exist) are brought in for entries not given but needed to complete the processing of the work order 10. Uses the data in the work order to generate the sequence flow for the input media

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
WOCPROC (Cont)	11. Displays processed work order display buffer on the CRT if either: a. Errors are detected during validation, or b. the work review option has been set. 12. Checks the operator's input for the accept, modify, or reject command. A work order in error may only be modified or rejected. If the CRT is not up when a work order is in error, the work order is rejected and an error log message is produced. If the review option is not specified, a correct work order is automatically accepted 13. Transfers an accepted work order to disk, updates the tape-ID data, and increments the summary log data. Optionally prints work order. 14. Rechecks a modified work order, drops a work order that is rejected, and clears the display buffer. Generates a log message when a work order is rejected 15. When a work order is transferred to disk it is placed in the TEMPWOC file unless the WOCFILE and the TEMPWOC file was empty at the activation of WOCPROC, it is then placed in the WOCFILE file. A message is sent to the OC when the WOCFILE is initially filled 16. An error return via the M:IOEX call (reprieve) results in pertinent information displayed on the operator's console and in the log followed by termination of WOCPROC 17. Following processing of work orders and if the TEMPWOC has data, checks status of the WOC-SHIFT-FLAG, and if set, transfers the TEMPWOC records to WOCFILE and copies the tape-ID information over to the scheduler common

Table A-1. EDIPS Software Module Functions (Cont)

Module	Functions
WOCPROC (Cont)	18. Exits with a log message giving the number of WOCs processed.
WRAPUP	1. Sets task-exit-flag and resumes all pseudo resident tasks
	2. Writes an EOF on the TIFT and rewinds the tape. Sends a message to the LOG giving TIFT label and number of records written
	3. Issues a LOG flush command to flush the LOG buffers onto disk
	4. Institutes dialogue as to activation of SEMS and LOG
	5. Writes dynamic data base to disk
	6. M:IOEX error causes termination of WRAPUP
	7. Aborts if activated when the scheduler is busy.

A-2. MODULE DESIGN

The design of the EDIPS software modules is embodied in Program Design Language (PDL) listings. The listings for each of the 36 modules represent EDIPS-unique software. These modules and the vendor-supplied software from SEL and FPS, together with the EDIPS hardware, constitute the operational EDIPS system.

Software module documentation using PDL has a number of useful features for both the designers and developers of software and the users:

a. Top down and structured programming permits the user to select the level of detail commensurate with the level of interest or need.

b. A segment reference tree listing shows the hierarchical relationship of the segment of interest to the total software package.

c. Information on data base parameters are presented in an easily maintained and progressive fashion.

d. Data items are processed by the PDL program to provide interface data which is then listed in the PDL in concise form.

e. The formatted (indented) output of logic, particularly nested loops, facilitates tracking the processing sequence.

f. The use of a minimum set of constructs (e.g., IF, ELSE, ENDIF, DO, ENDDO, etc.) provide for a uniformly formatted output for the software descriptions.

g. Coding from the detailed PDL is no more difficult than coding from detailed flow charts. If a structured higher-level language is used (e.g., SFORTRAN, IFTRAN, ALGOL, JOVIAL) the coding is considerably simplified.

h. The PDL is typically updated through a timeshare terminal, and a number of updated copies can be obtained in a few hours, if required.

A-3. PDL ORGANIZATION

The PDL for each module consists of a computer printout containing the following items:

a. Design Cover Page: Provides title, date, and processor identifier.

b. Table of Contents: Lists each group and its segments by page number.

c. Design Body: Consists of group title page, text segments, data segments, and external segments.

d. Segment Reference Trees: Contains the trees showing how the various flow segments are referenced. When a segment is referenced recursively, its name in the tree is prefixed with an asterisk and the recursion is not traced further. The page number of the segments definition is listed next to each name. For each root segment (i.e., a segment that is not called by any other segment, but which contains references to at least one segment) a new tree is listed.

e. Data Index: Contains a list of all data items in alphabetical order. To the left of each item, the page and line number of its definition is listed together with its type (currently DI for data item). Following each item is the referencing segment name, page, and line number of each occurrence.

f. Flow Segment Index: Lists each flow segment and external item in alphabetical order. To the left of each is the page and line number of its definition and the type of

entry (FS for flow segment and EI for external item). Following each item is the referencing segment name, page, and line number of each occurrence.

g. Final page: Displays the message END OF DESIGN and a list of processing statistics.

Figure A-1 illustrates representative pages from the EDIPS PDL listing.

TRW SYSTEMS GROUP
ONE SPACE PARK
REDONDO BEACH, CALIFORNIA 90278
(213) 535-4321

```
*************************************************************
*                                                           *
*                        EDIPS SCHACT                       *
*                                                           *
* THE EDIPS SCHACT MODULE CAUSES ACTIVATION OF THE EDIPS    *
*                                                           *
*  SCHEDULER AND IS USED TO ESTABLISH THE INTERFACE FOR     *
*                                                           *
*                ALL EDIPS PROCESSING MODULES.              *
*                                                           *
*                          08 NOV 77                        *
*                                                           *
*                          PDL 03.06                        *
*                                                           *
*************************************************************
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 1 of 18)

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Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 2 of 18)

OVERVIEW

```
SCHACT IS A SUBROUTINE THAT IS USED BY ALL EDIPS PROCESSING TASKS
TO LET THE SCHEDULER KNOW WHEN THEY ARE FINISHED WITH THEIR
PROCESSING. THEY RETURN 5 ARGUMENTS THAT ARE USED TO SPECIFY TO THE
SCHEDULER WHAT TASK TERMINATED, WHAT WOC BUFFER WAS USED BY THE TASK
DURING ITS PROCESSING, WHAT DISK CONTROLLER AND WHAT DISK UNIT WAS
USED, AND THE TERMINATION CODE USED BY THE TASK.
THIS ROUTINE WILL SET THE TASK NUMBER, THE WOC BUFFER NUMBER, THE
DISK UNIT NUMBER AND THE TERMINATION CODE INTO GLOBAL COMMON IN THE
TASK TERMINATION AREA INDEXED BY THE DISK CONTROLLER NUMBER. IF THE
TERMINATING TASK NUMBER IS 101 OR 102, IT WILL BE INDEX BASED UPON
THE HDT UNIT USED. THE TASK TERMINATION AREA USED WILL BE EITHER 4
OR 5 (DEPENDS UPON HDT 1 OR HDT 2). TASK INSRCH IS 101 AND TASK INMOUNT
IS 102. IF NO DISK CONTROLLER NUMBER IS USED (IE ZERO IS USED), THE
TASK TERMINATION AREA USED WILL BE EITHER 6, 7, OR 8. AREA 6
WILL BE USED IF CCT HAS NO DISK AND 7 OR 8 WILL BE USED IF INHDT
HAS NO DISK UNIT USED.
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 3 of 18)

FUNCTIONAL CAPABILITIES

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                                          +
+       1.) SCHACT SHALL HAVE THE CAPABILITY TO PASS VARIOUS PARAMETERS FROM              +
+           THE VARIOUS EDIPS MODULES TO GLOBAL COMMON. THE PARAMETERS AT                 +
+           A MINIMUM SHALL INCLUDE:                                                      +
+               A.) TASK NUMBER OF THE RETURNING USER                                     +
+               B.) THE INDEX TO THE PROPER WOC BUFFER ENTRY                              +
+               C.) DESIGNATION FOR THE OUTPUT DISK                                       +
+               D.) TERMINATION CODE                                                      +
+       2.) SCHACT SHALL CAUSE THE SCHEDULER TO BE RESUMED.                               +
+                                                                                          +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 4 of 18)

30400-6009-RU-00

CORE UTILIZATION AND TIMING

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                                     +
+   CORE                                                    (WORDS)                   +
+       DATA BUFFERS                                           0                      +
+         NONE USED                                            0                      +
+   ...                                                                               +
+                                                 SUBTOTAL     0                      +
+   ...                                                                               +
+   CODE                ESTIMATED LINES           MACHINE INSTRUCTIONS(WORDS)         +
+   ...                                                                               +
+       FORTRAN                35                            175                      +
+       ASSEMBLER               0                              0                      +
+   ...                                                                               +
+                                                  SUBTOTAL   175                      +
+   ...                                                                               +
+                                     ESTIMATED CORE TOTAL   175                      +
+   ...                                                                               +
+   TIMING                                                                            +
+   ...                                                                               +
+       NORMAL EXECUTION TIME FOR SCHACT WILL BE ABOUT 1.5 MILLISECONDS.              +
+       THIS INCLUDES THE TIME FOR THE RTM RESUME TO BE EXECUTED. THE                 +
+       TIME TO EXECUTE THE CODE WITHIN SCHACT WILL BE ABOUT 30 MICROSECS.            +
+   ...                                                                               +
+   ...                                                                               +
+                                                                                     +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 5 of 18)

```
    APPLICABLE DOCUMENTS

    ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    +                                                                                            +
    +  1     SEL REAL TIME MONITOR REFERENCE MANUAL,PUBLICATION NUMBER                            +
    +  2             323-321001-001/323-086001-C07                                               +
    +  3     EDIPS/PS SOFTWARE REQUIREMENTS, PUBLICATION NUMBER                                  +
    +  4             EDIPS-79                                                                    +
    +                                                                                            +
    ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 6 of 18)

```
TRW, INC.        EDIPS SCHACT                                                                    PAGE   13
08 NOV 77        EDIPS SCHACT MODULE INTERFACES

      EXTERNAL MODULE REFERENCES

      XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      X                                                                                                    X
      X  1     LOGGEN...CALL LGOUT(MSG)...WHERE MSG IS THE BUFFER CONTAINING THE TEXT TO BE PUT INTO THE 7X         86
      X              LOGFILE.                                                                              X
      X                                                                                                    X
      XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 7 of 18)

EXTERNAL DATA DEFINITIONS

```
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
D                                                                                                       D
D 1   TASK-TERMINATION-AREA BYTE (4,8) BINARY TTA = TERMINATING TASK NUMBER, WOC BUFFER NUMBER, /D      90
D           TERMINATION CODE, DISK NUMBER                                                   D
D 2   ... THE ITEMS IN THIS ARRAY ARE SET BY MODULE SCHACT. ITEMS (N,1) THRU (N,3) ARE INDEXED  /D      92
D           BY THE DISK CONTROLLER USED, WHILE ITEMS (N,4) AND (N,5) ARE RETURNED ONLY BY THE   /D
D           INSRCH OR INMOUNT TASKS AND ARE INDEXED BY THE HDT TAPE NUMBER USED. ITEMS (N,6)    /D
D           THRU (N,8) ARE INDEXED WHENEVER A DISK CONTROLLER OF ZERO IS GIVEN TO SCHACT. THIS  /D
D           CAN OCCUR ONLY FOR INHDT (TASK 1) OR FOR INCCT (TASK 2). IF IT OCCURS FOR ANY OTHER /D
D           TASKS A MESSAGE OF DISK CONTROLLER OUT OF RANGE WILL BE ISSUED.                     D
D 3   TERMINATED-UNIT-NUMBER...THIS VALUE IS EQUIVALENT TO ENTRY NUMBER (4,1) THRU (4,5) IN THE /D     100
D           ABOVE ARRAY. IT HOLDS THE DISK UNIT NUMBER OR THE HDT UNIT NUMBER.                  D
D                                                                                                       D
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 8 of 18)

INTERNAL DATA DEFINITIONS

```
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
D                                                                                                   D
D  1    TASK-NO...IS THE TERMINATING TASK NUMBER (1 THRU 8 OR 10)                                   D
D  2    WOC-BUFF-NO...IS THE WOC BUFFER NUMBER CURRENTLY BEING USED BY THE TERMINATING TASK.        D
D  3    DISK-CONTR...IS THE DISK CONTROLLER NUMBER (1 THRU 3)                                       D
D  4    DISK-UNIT....IS THE DISK UNIT NUMBER ON THE SPECIFIED CONTROLLER (1 OR 2); FOR INSRCH IT   7D
D             IS THE HDT UNIT NUMBER (1 OR 2)                                                       D
D  5    TERM-CODE...IS THE TERMINATION CODE USED BY THE TERMINATING TASK                            D
D                                                                                                   D
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 9 of 18)

PROCESSING LOG MESSAGES

```
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
D                                                                                      D
D 1     ..THE FOLLOWING MESSAGES ARE OUTPUT TO THE PROCESSING LOG VIA MODULE             D
D 2     ..LOGGEN. THEY ARE IDENTIFIED BY THE INTERNAL PARAMETER NAME AND                 D
D 3     ..INCLUDE THE MESSAGE PRIORITY, MESSAGE NUMBER, TASK ID, AND TEXT.              D
D 4     ..                                                                             D
D 5     ..NAME PRI NUM TASK MESSAGE                                                    D
D 6     ..                                                                             D
D 7     PLM01 2 01 SH SCHACT DISK CONTROLLER OUT OF RANGE                              D
D                                                                                      D
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 10 of 18)

OPERATOR CONSOLE MESSAGES

```
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
D                                                                                        D
D  1      ..THE FOLLOWING MESSAGES ARE OUTPUT TO THE OPERATORS CONSOLE                   D
D  2      ..DIRECTLY BY SCHACT. THESE ARE IN ADDITION TO LEVEL 1 AND 2                   D
D  3      ..LOGFILE MESSAGES WHICH ARE OUTPUT TO THE OPERATORS CONSOLE                   D
D  4      ..BY MODULE LOGGEN WHEN THEY ARE PLACED IN THE LOGFILE. THEY                   D
D  5      ..ARE IDENTIFIED BY THE INTERNAL PARAMETER NAME AND THE MESSAGE                D
D  6      ..TEXT                                                                         D
D  7      ..                                                                             D
D  8      ..NAME MESSAGE TEST                                                            D
D  9      ..                                                                             D
D 10      PLM01 SCHACT DISK CONTROLLER OUT OF RANGE                                      D
D 11      ...                                                                            D
D 12      ...                                                                            D
D                                                                                        D
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
```

Table A-1. Examples of Program Design Language (PDL) Listing (Sheet 11 of 18)

TEST PLAN

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                          +
+   IN ORDER TO DEMONSTRATE THE FUNCTIONAL CAPABILITIES ATTRIBUTED          +
+   TO SCHACT, THE TEST PLAN SHALL DEMONSTRATE THE REQUIRED PERFORMANCE    +
+   LEVEL UNDER EITHER NORMAL OR ABNORMAL MODES OF OPERATION.  THE         +
+   FOLLOWING GENERAL TEST CLASSIFICATIONS ARE DEFINED TO DEMONSTRATE      +
+   THE REQUIRED PERFORMANCE:                                              +
+                                                                          +
+     A. NORMAL CONDITIONS                                                 +
+                                                                          +
+        1. ALL PARAMETERS WITHIN RANGE                                    +
+        2. RESUME SCHEDULER                                               +
+                                                                          +
+     B. ABNORMAL CONDITIONS                                               +
+                                                                          +
+        1. CALL WITH INVALID DISK NUMBER                                  +
+        2. SCHEDULER NOT RESUMED                                          +
+                                                                          +
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 12 of 18)

```
TEST OBJECTIVE

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                                                 +
+                                                                                 +
+     THE PRIMARY OBJECTIVE OF THIS TEST PLAN IS TO DEMONSTRATE                   +
+     SATISFACTORY EXECUTION OF SCHACT UNDER EITHER NORMAL OR                     +
+     ABNORMAL CONDITIONS.  THE OBJECTIVE SHALL BE MET BY ATTRIBUTING             +
+     ONE OR MORE FUNCTIONAL CAPABILITIES TO EACH TEST CLASSIFICATION;           +
+     THE ACTUAL TEST RESULTS SHALL PROVIDE THE MODULE PERFORMANCE                +
+     FOR THE TEST CLASSIFICATION, MODE AND CONDITION ASSOCIATED WITH             +
+     THE TEST.  IN THIS MANNER, THE FUNCTIONAL CAPABILITIES SHALL                +
+     BE DEMONSTRATED.                                                            +
+                                                                                 +
+     THE FOLLOWING COLUMNS RELATE THE FUNCTIONAL CAPABILITIES ATTRIBUTED         +
+     TO SCHACT TO THE TEST CLASSIFICATIONS DESCRIBED PREVIOUSLY.                 +
+                                                                                 +
+       FC1  - A.1, B.1                                                           +
+       FC2  - A.2, B.2                                                           +
+                                                                                 +
+                                                                                 +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 13 of 18)

```
SCHACT MAIN(TASK-NO,WOC-BUFF-NO,DISK-CONTR,DISK-UNIT,TERM-CODE)

REF
PAGE ***********************************************************************************
     *                                                                                 *
     *  1    ...TASK-NO IS THE TERMINATING TASK NUMBER (1 THRU 8 OR 101)               *      224
     *  2    ...WOC-BUFF-NO IS THE WOC BUFFER CURRENTLY USED BY THE TASK               *      225
     *  3    ...DISK-CONTR IS THE DISK CONTROLLER NUMBER (1 THRU 3)                    *      226
     *  4    ...DISK-UNIT IS THE DISK UNIT NUMBER USED ON THE CONTROLLER (1 OR 2); IN THE CASE OF  /*      227
     *             INSRCH THIS WILL BE THE HDT UNIT NUMBER                             *
     *  5    ...TERM-CODE IS THE TERMINATION CODE USED BY THE TASK                     *      229
     *  6    IF DISK-CONTR IS LESS THAN 0 OR OVER 3                                    *      230
     *  7        SET INDEX TO MINUS ONE                                                *      231
     *  8    ELSE                                                                      *      232
     *  9        SET INDEX TO VALUE OF DISK-CONTR...0 TO 3                             *      233
     * 10    ENDIF                                                                     *      234
     * 11    IF TASK-NO IS 101 OR 102                                                  *      235
     * 12        IF DISK-UNIT IS NOT 1 OR 2                                            *      236
     * 13            SET INDEX TO 0                                                    *      237
     * 14        ELSE                                                                  *      238
     * 15            SET INDEX TO 3 PLUS THE DISK-UNIT                                 *      239
     * 16        ENDIF                                                                 *      240
     * 17    ENDIF                                                                     *      241
     * 18    IF TASK-NO IS 1                                                           *      242
     * 19        IF INDEX IS 0                                                         *      243
     * 20            IF DISK-UNIT IS NOT 1 OR 2                                        *      244
     * 21                SET INDEX TO 0                                                *      245
     * 22            ELSE                                                              *      246
     * 23                SET INDEX TO 5 PLUS DISK-UNIT                                 *      247
     * 24            ENDIF                                                             *      248
     * 25        ENDIF                                                                 *      249
     * 26    ELSE IF TASK-NO IS 2                                                      *      250
     * 27        IF INDEX IS 0                                                         *      251
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 14 of 18)

```
TRW, INC.        EDIPS SCHACT                                                    PAGE    28.001
08 NOV 77        INDEX TO DATA ITEMS


INDEX TO DATA ITEMS
-------------------

PAGE  LINE  TYPE        NAME AND REFERENCES
----  ----  ----        -------------------

 17    3    DI          DISK-CONTR
                                27    SCHACT MAIN
                                            6     9

 17    4    DI          DISK-UNIT
                                27    SCHACT MAIN
                                           12    15    20    23    35

 18    7    DI          PLM01
                                27    SCHACT MAIN
                                           32

 17    1    DI          TASK-NO
                                27    SCHACT MAIN
                                           11    18    26    35

 15    1    DI          TASK-TERMINATION-AREA
                                27    SCHACT MAIN
                                           35

 15    3    DI          TERMINATED-UNIT-NUMBER

 17    5    DI          TERM-CODE
                                27    SCHACT MAIN
                                           35

 17    2    DI          WOC-BUFF-NO
                                27    SCHACT MAIN
                                           35
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 15 of 18)

INDEX TO FLOW SEGMENTS

PAGE	LINE	TYPE	NAME AND REFERENCES
13	1	ET	LOGGEN
			27 SCHACT MAIN
			32
27		FS	SCHACT MAIN

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 16 of 18)

```
TRW, INC.        EDIPS SCHACT                                          PAGE    30.001
08 NOV 77        SEGMENT REFERENCE TREES

SCHACT MAIN
-----------

LN  DEF    SEGMENT
--  ---    -------

 1   27     SCHACT MAIN
 2   13        LOGGEN
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 17 of 18)

```
*************************
*                       *
* END OF DESIGN DOCUMENT *
*                       *
*************************
```

```
PDL RUN TIME STATISTICS:
      264 INPUT CARDS PROCESSED
        1 FLOW SEGMENTS
    11700 WORDS OF CORE AVAILABLE,   4.1 PERCENT USED
```

Figure A-1. Examples of Program Design Language (PDL) Listing (Sheet 18 of 18)