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Generation and Physical Characteristics of the LANDSAT-1, -2 and -3 MSS Computer Compatible Tapes

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DECEMBER 1977

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FOREWORD

This document discusses the format and physical characteristics of the Landsat multi-spectral scanner (MSS) computer compatible tape (CCT). The resulting system corrected CCT has been generally referred to as the bulk MSS CCT.

The document is designed to be useful to those who are interested in knowing only general information about the system corrected MSS CCT as well as to those who have a need to know more details about the CCT. The overview section covers all of the general information. The second section (tape format) contains the necessary details for the data analyst or computer programmer who is interested in developing computer software which will read the CCT. The radiometric striping section and the appendices contain supplemental information about the radiometric striping characteristics, the radiometric calibration of the video data and other information that is beneficial to the reader.

The author gratefully acknowledges the assistance of Ms. Karen Denomme and Ms. Lottie Brown in updating the document so that it also applies to Landsat-3.

GENERATION AND PHYSICAL CHARACTERISTICS OF THE LANDSAT-1, -2 and -3 MSS COMPUTER COMPATIBLE TAPES

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ABSTRACT

This document discusses the generation and format of the Landsat-1, -2 and -3 system corrected multi-spectral scanner computer compatible tapes generated by the NASA Data Processing Facility after January 15, 1978. Included in the discussion are the spacecraft sensors, scene characteristics, the transmission of data, and the conversion of the data to computer compatible tapes at the NASA Data Processing Facility. Also included in the discussion are geometric and radiometric corrections, tape formats, and the physical characteristics of the tape.

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GLOSSARY

APT	Auxiliary paper tape
Bit	The smallest element of binary, computer-intelligible data
Byte	A unit of data consisting of eight bits
CCT	Computer compatible tape
DS	Digital subsystem
DPPS	Digital pre-processing system
EBCDIC	Extended binary coded decimal interchange code
ERTS	Earth Resources Technology Satellite (now known as Landsat)
GSFC	Goddard Space Flight Center
HDDT	High-density digital tape
IAT	Image annotation tape
ID	Identification
IIGS	Initial image generating subsystem
km	Kilometer
Landsat	Land Satellite (formerly ERTS)
LLC	Line length code
MSS	Multispectral scanner
NDPF	NASA Data Processing Facility
nm	Nautical mile
Nmax	Maximum line length code
Pixel	One video data byte
RBV	Return-beam vidicon
SIAT	Special Image Annotation Tape

GENERATION AND PHYSICAL CHARACTERISTICS OF THE LANDSAT-1, -2 AND -3 MSS COMPUTER COMPATIBLE TAPES

OVERVIEW

SPACECRAFT SENSORS

The Landsat Spacecraft contains in its payload two separate subsystems designed to produce spectral imagery of the Earth's surface: the return-beam vidicon (RBV) camera subsystem, and the multispectral scanner (MSS) subsystem.

RBV Camera Subsystem (For Landsat-1 and -2)

The RBV camera subsystem contains three individual cameras that operate in different nominal spectral bands from 0.475 to 0.830 micrometers. Each camera contains an optical lens, a shutter, an RBV sensor, a thermoelectric coder, deflection and focus coils, erase lamps, and the sensor electronics. Spectral filters in the lens assemblies provide separate spectral viewing regions for the cameras. The three cameras view the same nominal 185-kilometer square ground scene. When the cameras are shuttered, the images are stored on the RBV photosensitive surfaces, then scanned to produce video outputs.

MSS Subsystem

The MSS, for Landsat-1 and -2, is a four-band scanner operating in the solar-reflected spectral region from 0.5 to 1.1 micrometers. The MSS, for Landsat-3, consists of 5 bands; however, our discussion will cover only the four bands which correspond to the Landsat-1 and -2 scanner. The scanner consists of six detectors for each of the four bands. The MSS scans crosstrack swaths 185 km wide at normal altitude, imaging six scan lines across in each of the four bands simultaneously. This is accomplished by means of an oscillating flat mirror between the ground scene and a double-reflector telescope type of optical chain. The mirror scans the crosstrack field of view as it oscillates about its nominal position.

Video outputs from each detector in the scanner are sampled, digitized, commutated, and multiplexed into a modulated stream. The commutated samples are encoded and transmitted to ground-based receiving sites. The receiving sites compile the raw data on video tapes and transmit these tapes to the NASA Data Processing Facility (NDPF) at the Goddard Space Flight Center (GSFC), Greenbelt, Maryland.

The NDPF corrects, calibrates and formats the raw MSS data and converts it to a usable binary form on computer compatible tapes (CCT). Data processing operations discussed in this document include the formatting of digitized data on the CCTs, various corrections that are applied to the data to enhance its usefulness, and additional data processing such as decompression of data, radiometric calibration, and insertion of geographic coordinate tick mark information. For a more detailed description of these and other data processing operations at the NDPF, see "ERTS Data User's Handbook" and the appendices in this document.

This document discusses only Bulk four-band MSS CCTs.

DISCUSSION OF A SCENE

The annotated and corrected 185-km square ground scene on the CCT is a final product of the MSS. This scene provides a number of different types of information that can be of value to the data user. An understanding by the user of the several steps necessary to produce this product will aid him in obtaining fullest use of the MSS data.

Scan Lines

A scene is made up of parallel scan lines, each containing a large number of video data points. There are 2340 of these lines per completed MSS CCT scene. Each scan line covers a distance of 185 km and is comprised of from 3000 to 3450 "bytes" of video data. A byte is made up of eight binary "bits," which are the smallest units recognized by the computer. These eight-bit bytes (only six of the eight bits contain data in the linear mode, seven in the decompressed mode) are arranged in such a manner that they can represent differing radiance levels. The mirror motion since launch has thus far been highly repeatable. The scan line for a given scene has had an average of 3216±6 bytes per line for Landsat-1, and 3247±5 bytes per line for Landsat-2. The scan line average length for Landsat-3 will not be available until after launch. The deviation per scene is typically ± 1 in the worst case. The relationship between video data bytes and the corresponding ground area covered is discussed in Appendix A. Figure 1 shows the components of a completed ground scene.

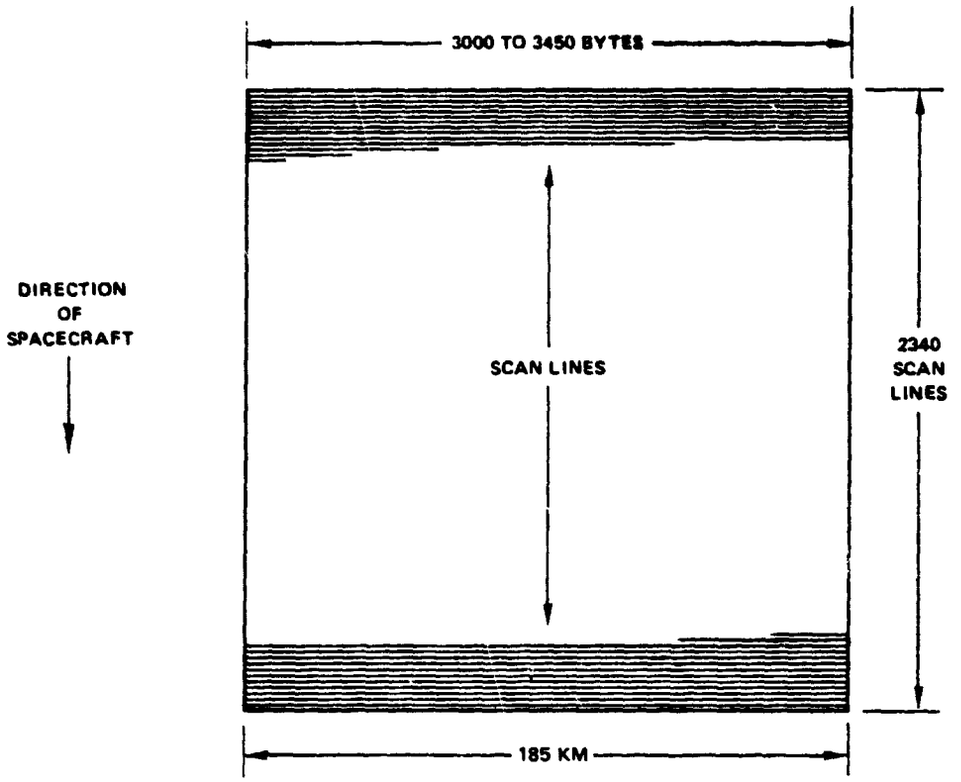


Figure 1. Components of a Completed Ground Scene as Represented on the MSS CCT

The distance covered by a scan line varies with altitude. Experience has shown that the variations have resulted in scan line changes of approximately ± 4 km in the worst case. At nominal altitude, 918.592 km (496 nm), the scan line is 185 km. Throughout the remainder of this document, nominal altitude conditions will be used.

Direction of Scan

The scan mirror operates in a scan-and-retrace cycle. The active portion of the scan is in a west-to-east direction. The full scan-and-retrace cycle produces a 185-km sweep by the detectors of the ground scene beneath the satellite. Figure 2 shows the composite scan pattern of the MSS.

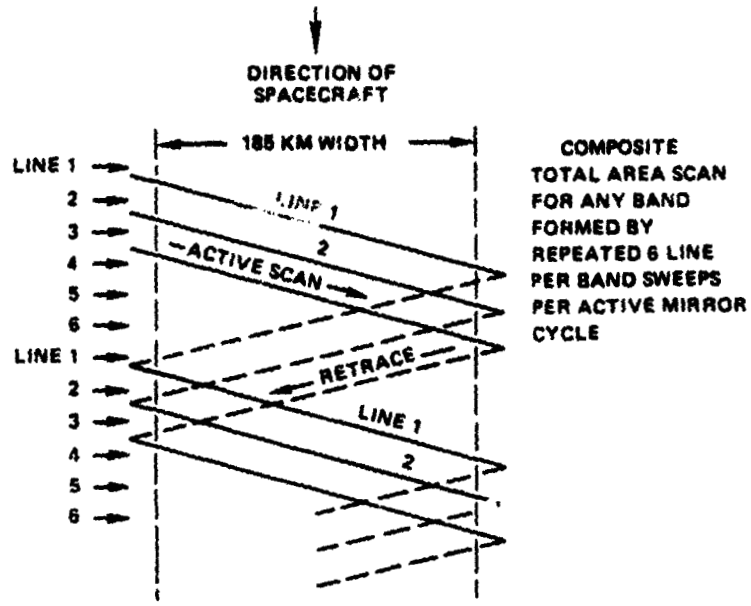


Figure 2. Ground Scan Pattern for a Single MSS Detector

Direction of Flight

The spacecraft's near-polar orbital motion produces the along-track spacing between mirror sweeps. This along-track scan pattern, when combined with the scan-and-retrace cycle, provides complete coverage of the full 185-km scene.

Sampling Rate

The video outputs of each detector are sampled during the active west-to-east sweep of the mirror. The sampling rate is a constant 100.5 kilo samples/sec and is maintained by an internal crystal clock.

Mirror Sweep

The 11.56-degree effective crosstrack field of view is scanned as the mirror oscillates ±2.89 degrees about its nominal position, as shown in Figure 3. The mirror scans in a west-to-east direction, imaging in each mirror sweep the six scan lines from each of the four bands.

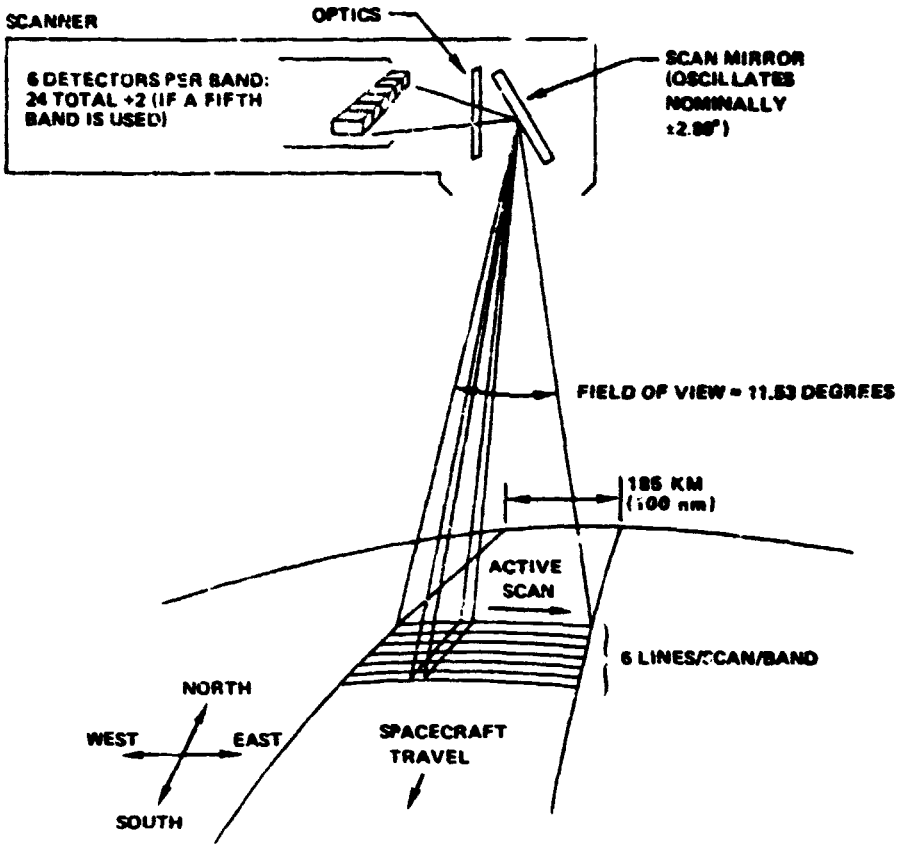


Figure 3. MSS Scanning Arrangement

Radiance Levels

Differing levels of radiance within a scene are represented by means of various combinations of bits in the scan lines. Radiance values are registered on a scale of from 0 to 63 (minimum to maximum) in the linear mode, and from 0 to 127 in the decompressed mode. To determine which mode the data is in, see the definition of "MSS data mode/correction code" in Table 1.

The Total Set of CCTs

One CCT contains an ID record, an annotation record, 780 line sets* of video data (which represent the interleaved data for a 42.25 by 185-km strip of the scene), for the four MSS spectral bands for Landsat-1, -2 and -3. The fifth band for Landsat-3 will not be included on

* A line set consists of 3 consecutive scan lines (see Fig. 17).

Table 1
ID Record Information Definitions

Char.	Information	Format	Code
1-12	Scene/Frame ID b = blank char.	EDDDD-HHMMSb*	EBCDIC
13-16	Tape Sequencing Numbers Tape N of M	bNbM	EBCDIC
17-18	Data Record Length (bytes)	nn	Binary
19-26	Binary Frame ID	nnnnnnnn**	Binary
27-28	Binary Strip ID	nn	Binary
29-36	IAT Identification from Header record on IAT	nnnnnnnn	EBCDIC
37-38	MSS Data Mode/Correction Code*** Unitary Code	nn	Binary
39-40	MSS Adjusted Line Length	nn	Binary

*E - Encoded Project Identifier
Landsat-1 - 1
Landsat-2 - 2
Landsat-3 - 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 - blank

**The Binary Frame ID is the binary representation of the Scene/Frame ID.

Char.
19 Encoded Project Identifier (same as *E above.)
20-21 Days since launch; this number is determined by extracting the six right-most bits from bytes (characters) 20 and 21 and combining them into one word (six bits from byte 20 followed by six bits from byte 21)
22 Hour at time of observation
23 Minute at time of observation
24 Tens of seconds at time of observation
25 Zero
26 Zero
For characters 22 through 26, the six right-most bits are used.

***Bits 0-7 of this two-character word are zero.
Bits 8-15 have the following significance:

Bit
8 = 1 for Sun Cal Data, = 0 otherwise
9 = 1 for Calibration Wedge, = 0 otherwise
10 = 1 for Compressed Data, = 0 otherwise
11 = 1 for Hi gain on Band 1, = 0 otherwise
12 = 1 for Hi gain on Band 2, = 0 otherwise
13 = 1 for Decompression, = 0 otherwise
14 = 1 for Calibration, = 0 otherwise
15 = 1 for Line Length Adjust, = 0 otherwise

CCTs at this time. A complete set of CCTs consists of: a) Four single CCTs; CCT 1, CCT 2, CCT 3, CCT 4, or b) two merged CCTs; CCT 1 and 2, CCT 3 and 4. The fourth CCT in single or merged copies, will also contain a Special Image Annotation Tape (SIAT) file. See Figure 18 for a diagram of the tape format.

Comparison of CCT Scene to Film Scene

The NDPF transmits completed ground scenes to data users on four separate CCTs, or two merged CCTs. For the single CCT copies, each tape contains image data for one 46.25- by 185-km strip. For the merged CCT copies, each tape contains image data for two strips. The CCTs contain more image data than does the corresponding film print. The additional data consists of 42 scan lines preceding and 42 scan lines following the data from which the film scene was made (the film contains 2256 scan lines). Figure 4 shows a scene as contained on four CCTs. The CCT scene and the film scene contain the same annotation data. Both the film and the CCT have the same algorithm applied to radiometrically calibrate the data; however, only the film is corrected for the mirror velocity profile. The film and CCT are both corrected for line length variation. The CCT is

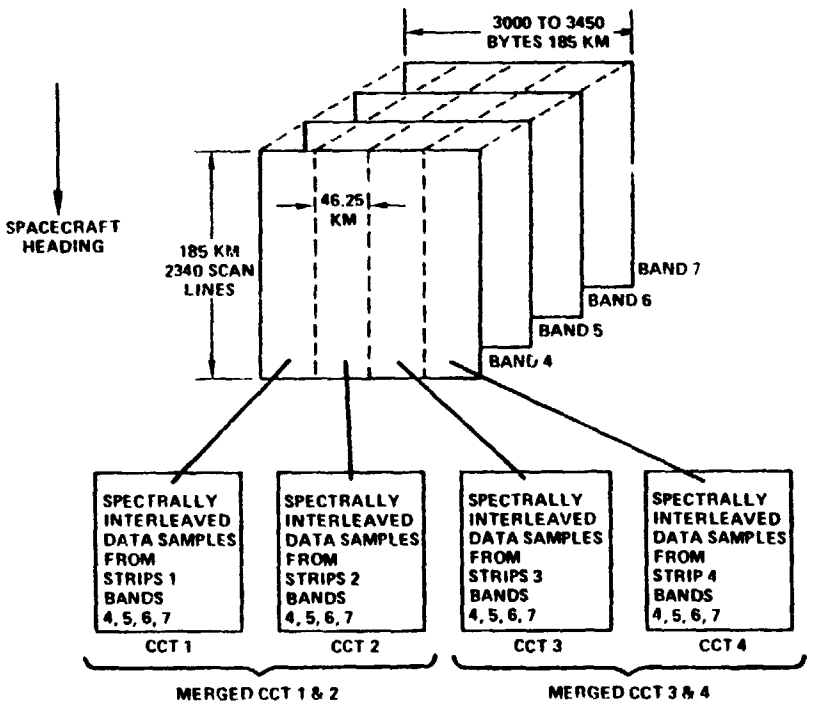


Figure 4. Bulk MSS Image-to-CCT Conversion

not geometrically corrected for effects such as skew as a function of Earth rotation or mapping projection.

Seven- and Nine-track CCTs

Data users should request either seven- or nine-track CCTs according to the requirements of their computer. This and other physical characteristics of magnetic tapes are discussed in Appendix B.

Spectral Range for Each Band

The MSS subsystem is used on three missions. The four spectral bands widths are as follows:

Band 4	0.5 to 0.6 micrometers
Band 5	0.6 to 0.7 micrometers
Band 6	0.7 to 0.8 micrometers
Band 7	0.8 to 1.1 micrometers

Bands 4 through 6 use photomultiplier tubes as detectors; Band 7 uses silicon photodiodes.

TRANSMISSION OF DATA

Registration of Scan Lines

The MSS detectors are sampled sequentially at a constant rate; therefore, the corresponding detectors of each band for the same ground field of view are not simultaneously sampled. Since the same ground field of view is not sensed by the detectors for each band at the beginning of the sampling, individual band pictures are misregistered in the along track scan direction by whole data samples.

The NDPF corrects for this slight variation by inserting registration fill characters (which contain no useful video data) at the ends of the lines. Registration fill characters correspond to bytes, and the number added to a given scan line is always six. These six characters are inserted at either or both ends of a scan line, as shown in Figure 5. Fill characters are added to the scan lines of each of the four spectral bands.

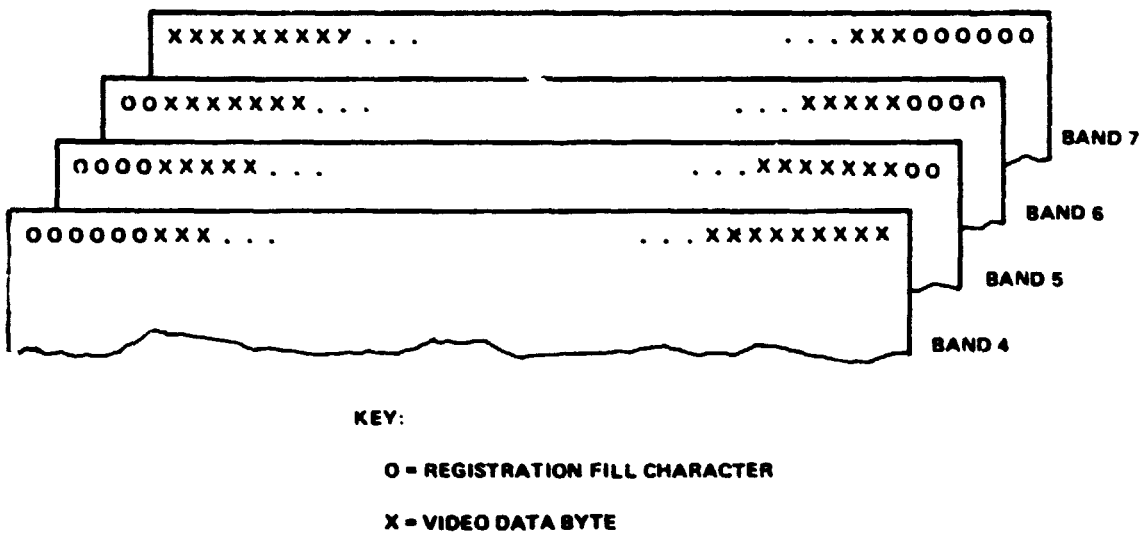


Figure 5. Position of Registration Fill Characters in Spectral Bands

Line Length Adjustment

Because the length of the scan lines that comprise a scene may vary slightly due to small variations in the period of the mirror, NDPF performs a line length adjustment operation on the computer to adjust all scan lines on ground scenes to the same length. The scan lines are lengthened by inserting "synthetic" bytes at regular intervals as needed to attain the length of the adjusted line. This line length adjustment produces negligible distortion of the imagery. See Appendix C for a discussion of how line length adjustment is calculated.

Radiometric Calibration

During every other retrace interval a shutter wheel closes off the optical fibers viewing the Earth and an artificial light source is projected into them through a variable neutral density filter on the shutter wheel. This process

introduces a calibration wedge into the video data stream of Bands 4 through 7. The nominal shape of this calibration wedge, referred to as the gray wedge, is shown in Figure 6. The actual shape and level vary somewhat among the four spectral bands.

The fact that the calibration lamp intensity profile is constant makes it possible to check the relative radiometric levels, and also to equalize gain changes which may occur in the six detectors of a spectral band. Corrections are performed at the NDPF to equalize these levels so that striping will be avoided. Appendix D provides an explanation of the radiometric calibration procedure.

Decompression of Data

The signal compression mode is normally used for the data from Bands 4 through 6 (photomultiplier tubes) since these bands have a better signal-to-noise performance than Band 7 (silicon photodiodes). By compressing the higher light levels and expanding the lower levels, the quantization noise more nearly matches the detector noise. Because of the performance characteristics of silicon photodiodes, no signal compression is performed on Band 7.

Decompression of MSS data at the NDPF consists of converting the data points to an expanded format that is easier to use. The MSS data are decompressed by means of a computer program which utilizes a decompression look-up table. This decompression table appears in Appendix E.

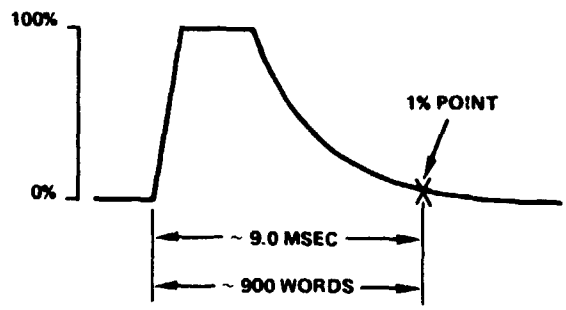


Figure 6. Nominal Calibration Wedge Output

Annotation

The annotation record on CCTs is in two parts. The first part is background information concerning conditions under which the data were taken, such as sun angles, etc. The second part provides tick mark location information so that the ground scene can be located in terms of geographic coordinates. The annotation record follows the ID record on the CCT and immediately precedes the video data.

INTERLEAVING OF DATA

Data from the four spectral bands are combined on the CCT through a process called interleaving. Bytes of data from the bands are interspersed by twos to produce an eight-byte "Group." The Group is the smallest element of interleaved data.

In addition, the first and last three Groups of each scan line contain registration fill characters to correct for misregistration among spectral bands. This registration process is discussed more fully in the Tape Format Section of this document.

TAPE FORMAT

The MSS CCT is made up of four groups of records: ID, annotation, video data, and SIAT data. The ID record contains a combination of binary and EBCDIC information which is used to identify the video data on the CCT. The annotation record contains binary and EBCDIC data which provide additional information about the scene, such as the format center, nadir and sun elevation. This record also includes tick mark location information which associates the digitized scene with the latitude and longitude coordinate system. The video data record contains scene information which has been digitized so that each data point is represented by a radiance value which varies from 0 to 63 if the data are linear, and from 0 to 127 if the data are decompressed. The SIAT data are written in a separate file following the data on the fourth of the CCT set.

ID RECORD

The 40-byte ID record is the first record on the tape, and appears only once per tape. Figure 7 shows the organization of the ID record.

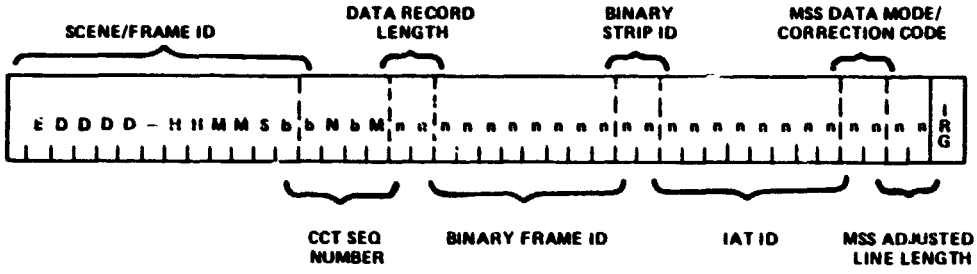


Figure 7. ID Record Organization (40 Characters, EBCDIC and Binary Code)

The first word in the ID record is the scene/frame ID, given in terms of days, hours, minutes, and tens of seconds since launch. In addition, this record indicates whether the data are from Landsat-1, -2 or -3. Characters 13-16 contain the sequencing numbers, i.e., 1 of 4, 2 of 4, etc., which distinguish the tapes in the set of four. Characters 17-18 contain the data record length in binary, i.e., the length of the adjusted scan line plus 56 bytes of calibration information. Characters 19-26 contain the binary frame ID, which is the binary representation of the scene/frame ID and must be broken into days, hours, minutes, seconds, etc., to be read. See Figure 8 for a computer printout of a sample ID record. The binary strip ID is stored in characters 27-28; however, this ID is not used for Bulk MSS CCTs. Characters 29-36 contain the image annotation tape (IAT) ID, which identifies the IAT used in making the CCT. Characters 37-38 contain the MSS data mode/correction code, which is a digital word that indicates the characteristics of the data such as decompression, calibration, and line length adjustment. See Table 1 for the complete definition of the MSS data mode/correction code. Characters 39-40 contain the MSS adjusted line length.

ANNOTATION RECORD

The annotation record is the second record on the tape. It occurs once per tape and contains 624 characters. The

```
******* ID  RECORD ********

SPECTRAL BAND 0                    SCENE/FRAME ID100530 16H 48M 2S
CCT SEQ. NO.  1 OF 4   DATA RECORD LENGTH  3296
BINARY FRAME ID 50531648200        BINARY STRIP ID     0
IMAGE ANNOT. ID  SI510103
MSS DATA MODE/CORRECTION CODE 00100111
MSS ADJUSTED LINE LENGTH  3240
```

Figure 8. Computer Printout of a Sample ID Record

annotation record is a composite of two records taken directly from the image annotation tape. The first 144 characters comprise the annotation block, and the next 480 characters comprise the image location record. Figure 9 defines the sequence of information in the annotation record.

Annotation Data Block

The information taken from the annotation tape is in human readable format to allow user interpretation. These data are specified at the time of RBV exposure or at the center

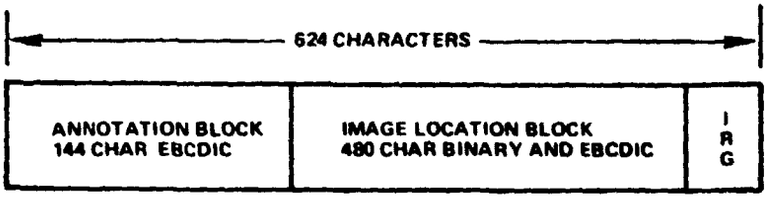


Figure 9. Annotation Record Information Sequence

of the MSS frame. All decimal points and special characters are included. The annotation block data format consists of 144 EBCDIC characters (72 sixteen-bit words). The format and content of the characters are defined in Table 2. Sample output from the Val Dump program (Figure 10) illustrates the type of information that is available in the first 144 characters of the annotation record.

```
**** ANNOTATION RECORD ****

AGENCY: NASA  PROJECT: ERTS-5  FRAME ID:0053DY 16HR 48MN 25S

EXPOSURE   FORMAT CENTER      NADIR
 DATE       LAT.   LONG      LAT.   LONG
 11JUN75   N32-47 W106-15   N32-48 W106-08

SUN ANGLES          ORBIT  STATN   IMAGE     EPHEM.
 EL    AZ            REV           SIZE      DATA
 58    099          4683          100X100NM   D

                    RBV 1   RBV 2   RBV 3
SHUTTER SETTING
DUR. OF EXP.         ---     ---     ---
APERT. CORR. IND.
TRANSM.

MSS DATA   ACQUIS.
           SITE
   D         3
```

Figure 10. Sample Output from the Val Dump Program

Table 2
Annotation Block Data

Characters	Description
1-2	Date of Exposure, day of month, numerals
3-5	Date of Exposure, month of year, abbreviated to three alpha characters
6-7	Date of Exposure, year, abbreviated to two numerals
8-10	Constant: 'bCb' (signifies Format Center) The center of the MSS image format is indicated in terms of latitude and longitude in degrees and minutes. The format center is defined as the geometric extension of the spacecraft yaw attitude sensor axis to the Earth's surface
11	Latitude direction, 1 alpha, N or S
12-13	Latitude, degrees, two numerals
14	Constant: '-'
15-16	Latitude, minutes, two numerals
17	Constant: '/'
18	Longitude, direction, 1 alpha, E or W
19-21	Longitude, degrees, three numerals
22	Constant: '-'
23-24	Longitude, minutes, two numerals
25	Constant: 'b'
26	* Direction of Spacecraft, 'D' for descending, 'A' for acsending
27-29	* Nominal path identifier, ranges from 1 to 251, three numerals
30	Constant: '-'
31-33	Nominal raw identifier, ranges from 1 to 248, three numerals
34	Constant: 'b'
35-36	Constant: 'Nb' (signifies Nominal).
37	Latitude direction, 1 alpha, N or S

*Value may be zero for some retrospective imagery acquired prior to February 22, 1977.

Table 2
Annotation Block Data (continued)

Characters	Description
38-39	* Latitude, degrees, two numerals
40	Constant: '-'
41-42	* Latitude, minutes, two numerals
43	Constant: '/'
44	Longitude direction, 1 alpha, E or W
45-47	* Longitude, degrees, three numerals
48	Constant: '-'
49-50	* Longitude, minutes, two numerals
51	Constant: 'b'
52	Sensor code, 'M' for MSS Spectral band-designated by one of the following four bytes:
53	Constant: 'b'
54	Constant: '4' or 'b'
55	Constant: '5' or 'b'
56	Constant: '6' or 'b'
57	Constant: '7' or 'b'
58-59	Constant: 'bb'
60	Transmission mode, 'D' for direct transmission, 'R' indicates stored data played back from the satellite wide band video tape recorder
61-67	Constant: 'bSUNbEL'
68-69	Sun elevation, degrees, two numerals Sun elevation angle at the midpoint of the MSS frame is specified to the nearest degree
70-71	Constant: 'bA'
72-74	Sun azimuth, degrees, three numerals Sun Azimuth - The sun azimuth angle from true North at the midpoint of the MSS frame is specified to the nearest degree
75	Constant: 'b'
76-87	Constant: 'U1L-CD-NbLab'
88-100	Constant: 'NASAbLANDSATb'

* Value may be zero for some retrospective imagery acquired prior to February 22, 1977.

Table 2
Annotation Block Data (continued)

Characters	Description
101-113	Scene Identification, E-DDDD-HHMMSb E - Encoded project identifier LANDSAT 1 - 1 LANDSAT 2 - 2 LANDSAT 3 - 3 DDDD - Day number relative to launch at time of observation;bDDD for some tapes generated between Feb. and May 1978. HH - Hour at time of observation MM - Minute at time of observation
114	Constant: '-'
115-116	Constant: 'bb'
117-140	Reserved for RBV
141-142	Direct or recorded MSS data: 'Db' or 'RD'
143-144	MSS data acquisition site, 'A-', 'G-', 'N-'

Image Location Data

The image location data consist of 240 sixteen-bit words which describe the tick marks that associate the scene with latitude and longitude. There can be a maximum of six tick marks per side (i.e., left side, right side, top and bottom), and the image location data includes the tick marks for Bulk RBV (Landsat-1 or -2) as well as Bulk MSS data.

The tick mark location data consist of four fields: the tick position, the special tick character, the direction (N, S, E, or W), and the value in degrees and minutes. Each tick mark is denoted by a 16-bit signed integer fraction which specifies its position along the edge of the scene, followed by eight EBCDIC characters. See Table 2 for a detailed description of the tick mark location information.

The 16-bit signed integer fraction represents the location of the tick mark along the edge of the scene and takes on values from +1/2 to -1/2. The most significant bit of the integer fraction indicates the sign of the fraction. If the bit is a one, the fraction is negative and is two's complement; if it is a zero, the fraction is positive. See Appendix F for a discussion of the tick mark reference system, and Appendix G for a sample hexadecimal-decimal fraction conversion table.

The special tick characters are either an X'4F', an EBCDIC vertical bar which is used along the top and bottom edges of the scene, or an X'7E', an EBCDIC equals sign which is used to represent the ticks on the left and right sides of the scene. The direction is represented by an EBCDIC character which represents north, south, east, or west (N, S, E, or W). The value of the latitude or longitude is given in degrees (3 characters) and minutes (2 characters).

There are two formats used to represent the location of tick marks. The tick marks are usually written first and are followed by the value of the latitude or longitude. If there is not enough room on any one of the sides for the last tick mark, then the value of the latitude or longitude is written first and is followed by the tick character for the last tick mark. An illustration of the two tick mark formats follows:

Format 1

Position: 16-bit signed binary fraction
Tick mark annotation:
    Tick mark character: X'4F' or X'7E'
    Direction, one character: N, S, E, or W
    Value
        Degrees, three characters:
        Constant: '-'
        Minutes, two characters: 00 or 30

Format 2

Position: 16-bit signed binary fraction
Tick mark annotation:
    Direction, one character: N, S, E, or W
    Value, six characters: same as Format 1
    Tick mark character: X'4F' or X'7E'

Each of the eight tick mark tables (one for each MSS and RBV edge) contains the tick mark data arranged in positional order from the top of the table downward. The unused tick mark locations are signified by a zero in the position words and X'FF' in all of the annotation characters.

The tick mark record format defined in the 16-bit words is as follows:

RBV tick mark set (Landsat-1 and -2 only):

Character	Description
B(1)	Position, tick mark no. 1
B(2) - B(5)	Annotation, tick mark no. 1
B(6)	Position, tick mark no. 2
B(7) - B(10)	Annotation, tick mark no. 2
B(11)	Position tick mark no. 3
B(12) - B(15)	Annotation, tick mark no. 3
B(16)	Position, tick mark no. 4
B(17) - B(20)	Annotation, tick mark no. 4
B(21)	Position, tick mark no. 5
B(22) - B(25)	Annotation, tick mark no. 5
B(26)	Position, tick mark no. 6
B(27) - B(30)	Annotation, tick mark no. 6
B(31) - B(60)	Left edge tick mark table
B(61) - B(90)	Right edge tick mark table
B(91) - B(120)	Bottom edge tick mark table

MSS tick mark set:

Character	Description
B(121) - B(240)	Format is the same as that for the RBV tick mark set

Figure 11 is a Val Dump printout of the MSS tick mark location information.

VIDEO DATA RECORD

Data Word

The data word consists of eight bits, of which only six are used if the data mode is linear and seven are used if the data mode is decompressed. The following illustrates the data word for the two modes:

Linear

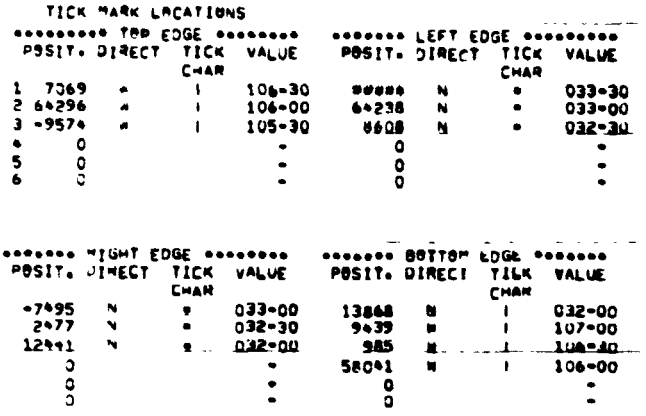
0	0	X	X	X	X	X	X
1	2	3	4	5	6	7	8

Decompressed

0	X	X	X	X	X	X	X
1	2	3	4	5	6	7	8

The X's represent the video data bits in the word. The bits in the diagram which contain the O's are used to indicate flags (e.g., 11111111 is used as the registration fill character).

The value of data within the data word varies from 0 to 63 in the linear mode and from 0 to 127 in the decompressed mode, and represents the variation of the radiance level (0 represents black, 63 or 127 represents white and the values in between represent all the shades of gray).



TICK MARK LOCATIONS

	TOP EDGE				LEFT EDGE			
	POSIT.	DIRECT	TICK CHAR	VALUE	POSIT.	DIRECT	TICK CHAR	VALUE
1	7369	*	I	106-30	*****	N	*	033-30
2	64296	*	I	106-00	64238	N	*	033-00
3	-9574	*	I	105-30	6608	N	*	032-30
4	0			-	0			-
5	0			-	0			-
6	0			-	0			-

	RIGHT EDGE				BOTTOM EDGE			
	POSIT.	DIRECT	TICK CHAR	VALUE	POSIT.	DIRECT	TICK CHAR	VALUE
	-7495	N	*	033-00	13868	N	I	032-00
	2477	N	*	032-30	9439	N	I	107-00
	12491	N	*	032-00	985	N	I	106-30
	0			-	58041	N	I	106-00
	0			-	0			-
	0			-	0			-

Figure 11. Val Dump Printout of MSS Tick Mark Location Information

Group

In order to obtain a video data record which includes information from all four spectral bands, the data from the bands are combined in a process called interleaving. This is an operation in which two bytes of data from each band are interleaved to produce an eight-byte "group," which is the smallest element of interleaved data. Figure 12 shows the scheme used to interleave the four bands of MSS data. The data samples in the group are registered and represent the same two points on the ground, as sensed by each of the spectral bands.

Registration fill characters are included in the first and last three groups; i.e., the first three groups of each quarter scan line on tape 1 of 4 and the last three groups of each quarter scan line on tape 4 of 4. In the illustration of these groups which follows, the 0's present registration fill characters and the X's represent video data bytes:

First three groups

00 00 00 XX 00 00 XX XX 00 XX XX XX

Last three groups

XX XX XX 00 XX XX 00 00 XX 00 00 00

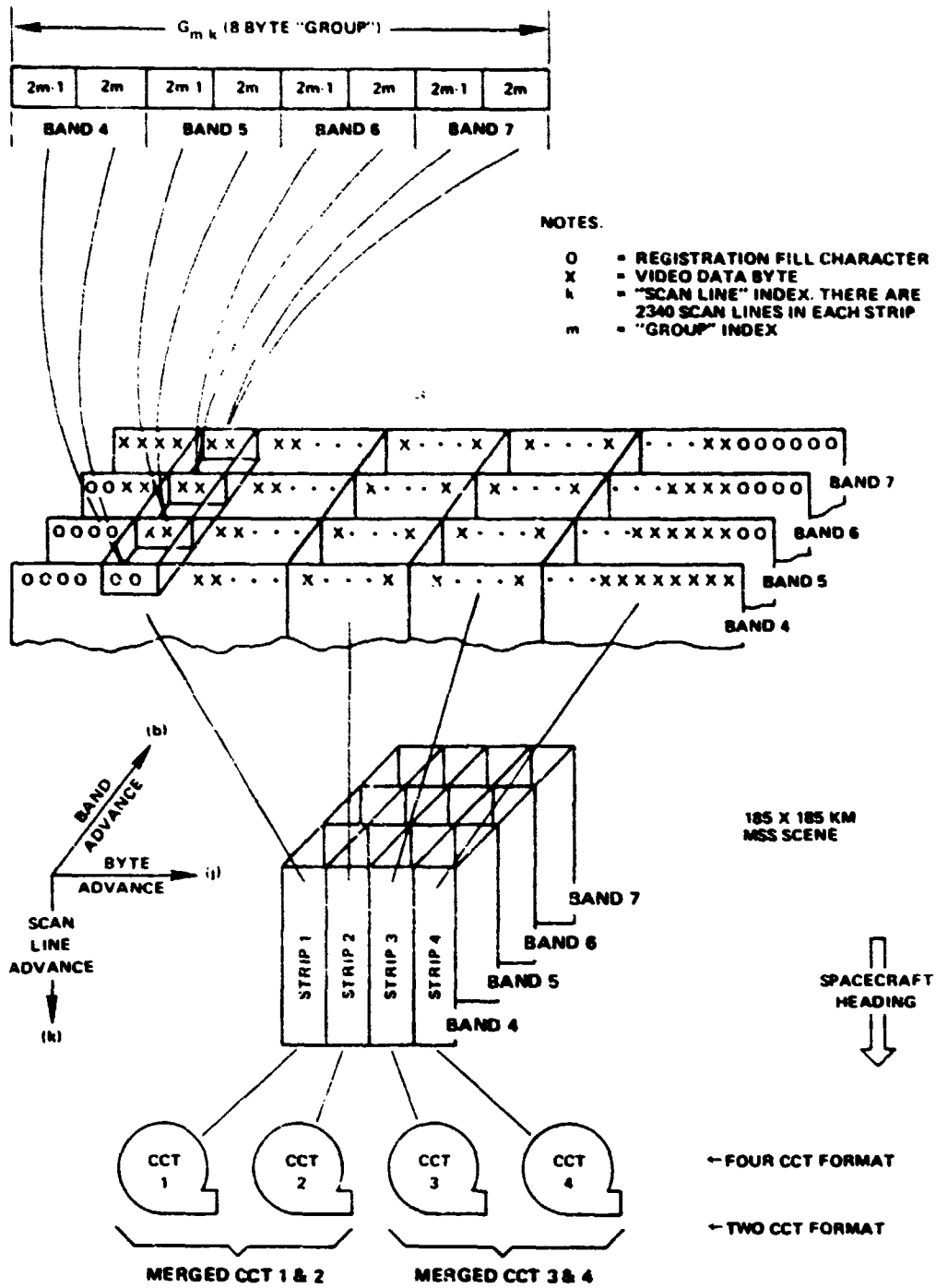


Figure 12. Bulk MSS Four-Band Scene to Interleaved CCT Conversion

Since the length of scan lines varies slightly, the adjusted scan line length is used to determine the number of groups (3n eight-byte groups) per scan line. The n referred to is the same n that is used in adjusting the scan line length. See Appendix C for an explanation of the line length adjustment.

Video Data Record for Landsat

The Landsat video data record ($R_{i\ k}$) consists of 3n eight-byte groups and four 14-byte calibration groups. Figure 13 illustrates the record format; i denotes the image segment and the CCT tape number, and k is the sequential scan line index.

The four 14-byte calibration groups contain calibration data for each of the four MSS bands. Each group contains six calibration wedge samples, a sun calibration coefficient, correction coefficients (filtered offset and filtered gain), and the value of the unadjusted line length for a band. Figure 14 gives the breakdown of the calibration data. The b denotes the band and the k denotes the scan line. Figure 15 shows the Val Dump printout of the calibration data.

Figure 16 is a sample Val Dump output of an MSS video data record. The printout is in hexadecimal. Note that in this example, tape 1 of 4 is used; therefore, the registration fill characters (X'FF') appear within the first data bytes.

Missing Data Flags

If data for a scan line is lost while making a CCT, a flag (X'CCCC' or, in the binary representation, 1100 1100) is inserted at the beginning of the scan line (on tape 1 of 4 only).

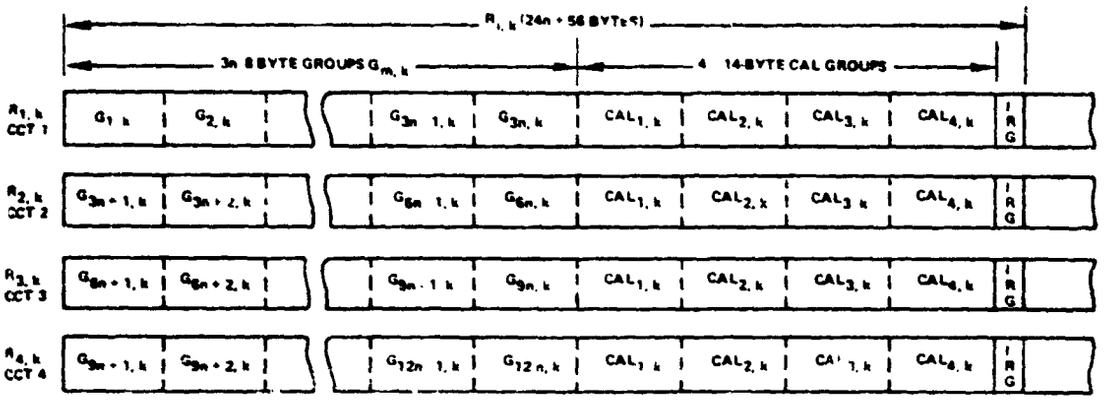
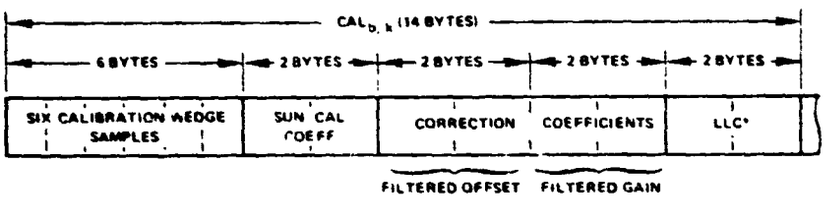


Figure 13. Bulk MSS Full Scene Interleaved Record Format (Line Length Adjusted to N=24n Samples)



*LLC is a 2 byte binary number denoting the number of video data samples per uncorrected (raw) scan line

THE LOCATION OF EACH BINARY POINT IS AS FOLLOWS:

SUN CAL	XXXX	XXXX	XXX.X	XXXX	
FILTERED OFFSET	XXXX	XXXX.	XXXX	XXXX	
FILTERED GAIN (LINEAR)	XXXX	XXXX.	XXXX	XXXX	
FILTERED GAIN (DECOMPRESSED)	XXXX	XXXX	XXX.X	XXXX	
$\hat{U}_{kn}$	XXXX	XXXX	XXXX	XXXX	(DISCUSSED IN APPENDIX D)

Figure 14. Bulk MSS Calibration Group Detail

CALIBRATION DATA

BAND, LINE	CAL WEDGE						SUN CAL COEFF	CORRECTION COEFFS.		LLC
CAL1,	1	40	36	10	14	5	2	1.0	1.21	45.3	3219
CAL2,	1	46	42	20	18	12	9	1.0	0.54	51.68	3219
CAL3,	1	54	45	37	16	14	12	1.0	0.62	67.22	3219
CAL4,	1	33	25	26	8	5	4	1.0	0.0	64.0	3219

Figure 15. Val Dump Printout of Calibration Data

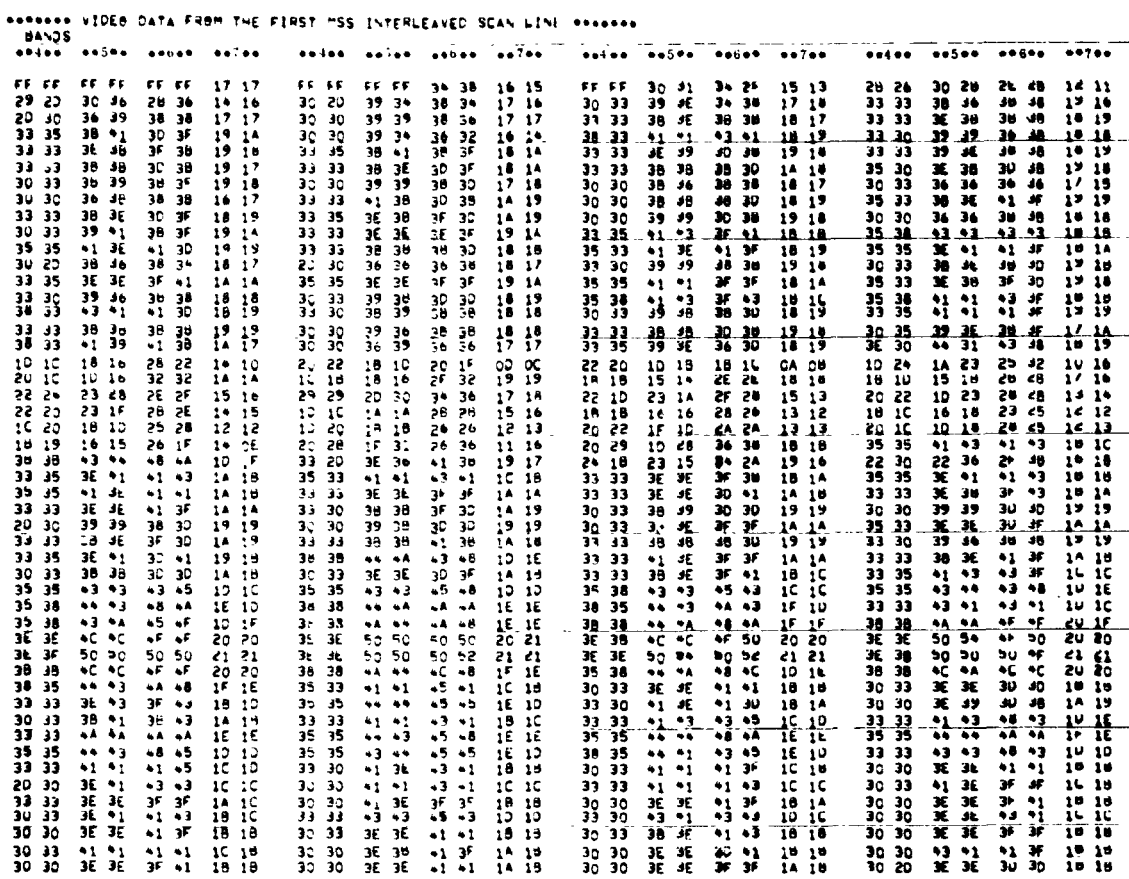


Figure 16. Sample Val Dump Output of an MSS Video Data Record (See Appendix G for hexadecimal-to-decimal conversion.)

Line Set

The line set (L_i, p) consists of three video data records. Figure 17 is a diagram of the line set. Figure 18 diagrams the line set grouping for the four-CCT format.

SIAT Data File

This file, as described in Appendix H, consists of eight records. The first record is a 2048 byte record which contains the SIAT logical tape header. The second record contains 268 bytes of the calibration modifiers (M's and A's). The third record contains 222 bytes of Processing Information Data. The fourth record contains 160 bytes of Spacecraft and

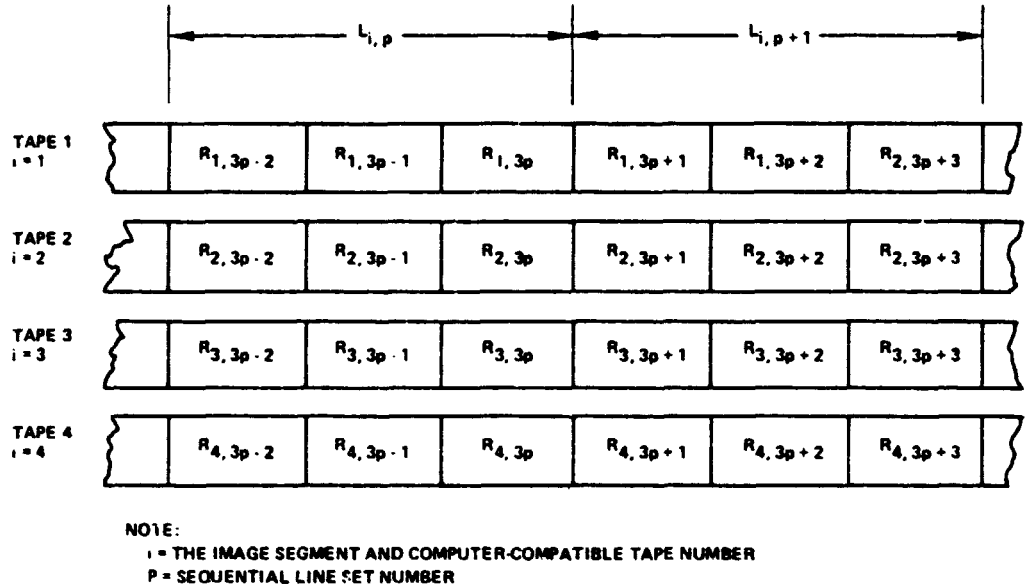


Figure 17. Bulk MSS Full Frame Line Set

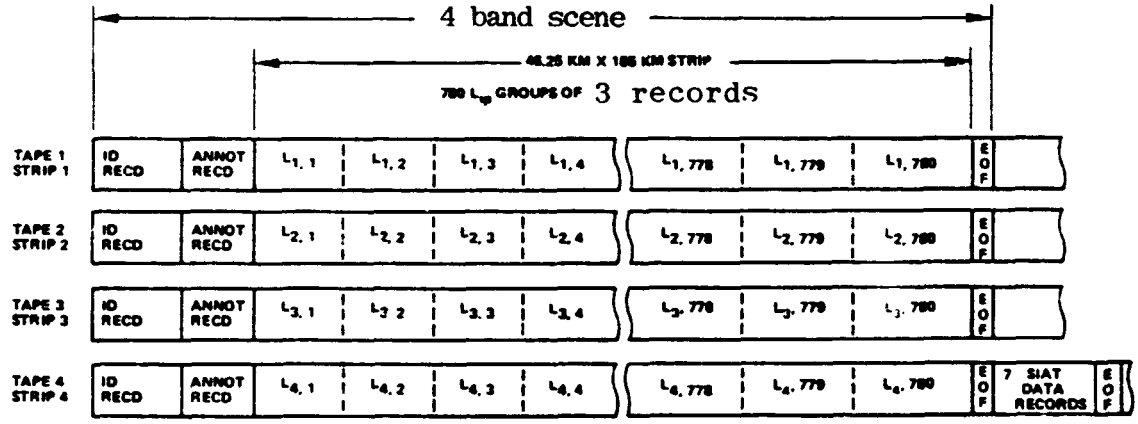


Figure 18. Bulk MSS Full Scene, Four-CCT Format

Sensor Performance Data. The fifth record contains 144 bytes of Annotation Block Data (Table 2). The sixth record contains 76 bytes of RBV Computational Data. Record seven contains 326 bytes of MSS Computation Data. The eighth record contains 480 bytes of Image Location Data.

A detailed description of each of these files is shown in Appendix H.

RADIOMETRIC STRIPING WITHIN VIDEO DATA ON CCTs

Striping problems in CCT video data can be divided into three basic types: radiometric striping, sixth line striping, and intermittent problems which appear to be striping.

RADIOMETRIC STRIPING

Radiometric striping is characterized by variations in the film density of imagery which should be uniform. These variations are repeatable and are present in the digital data in the same manner.

This type of striping is due to slight differences in sensitivity among the detectors. To compensate for this variation in detector output, gains and offsets are used which are calculated from regression coefficients that operate on the cal wedge of each detector.

The regression coefficients (for Landsat-1) used before April 1973 were based on prelaunch evaluations. Radiometric sensitivity, however, changed slightly after launch, causing a striping problem. In April 1973, new regression coefficients were selected which effectively eliminated the radiometric striping problem.

In July 1977, a further attempt was made to remove striping. This was accomplished through the addition of constant modifiers which are applied to the imagery after the data are normally calibrated. These radiometric calibration modifiers are referred to as M's and A's, constant multipliers (per detector) and constant adders (per detector) respectively. Each constant is changeable through software. The M's and A's appear in the SIAT file as record 2.

Appendix I provides information on detector-to-detector radiometric accuracy.

SIXTH LINE STRIPING

This striping is characterized by a variation in every sixth scan line of six quantum levels or more from the average quantum level of the other scan lines.

This striping problem was caused by an intermittent hardware problem in the MSS controller in IIGS, and was corrected through modification of the software in April 1973.

INTERMITTENT PROBLEMS

This class of problems occurs so intermittently that a solution has not been determined to correct for them. These problems include partial sync loss, full sync loss, track loss or disable, bit slips, and demux noise. These problems, along with their causes and effects, are listed in Table 3.

Table 3
Causes and Effects of Intermittent Striping Problems

Problem	Cause	Effect
Track loss or disable	Inoperative track on FR1928 tape recorder or MSS controller unable to find sync	Zeros are stored on the CCT for a detector or detectors, line length code, cal wedge, etc.
Partial sync loss	Complete loss of data/sync for one or several scan lines	Zeros stored on the CCT for a detector
Bit slips	Data not decoded properly by the FR1928 tape recorder	Missing scan line, or portion of scan line contains zeros
Demux noise	The demultiplexer occasionally adds noise to the data as it is being transferred to the ground from the spacecraft	Intermittent zeros appear in the video for a detector
Full sync loss	Loss of sync for all six detectors of a band	All zeros on the CCT for video data, line length code and cal wedge

Note:
Updated Landsat-2 calibration constants were calculated shortly after launch to reduce striping in several detectors. The results of a study (June 1975) involving the detector-to-detector striping indicated that the RMS striping is less than one MSS level for every detector on Landsat-2.

APPENDIX A

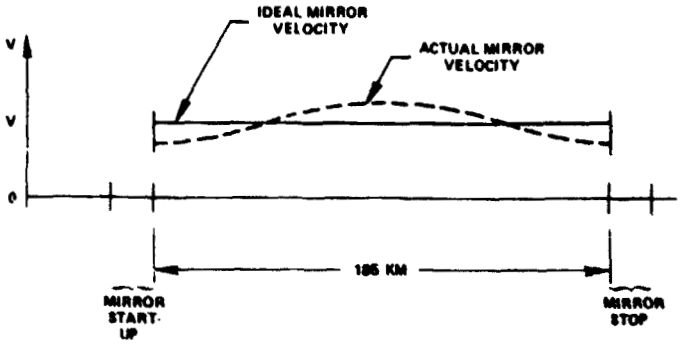
DISTANCE BETWEEN MSS CCT VIDEO DATA BYTES AND THE CORRESPONDINC GROUND AREA COVERED*

During the MSS scan of the ground, the video data bytes correspond to 260 by 260 foot areas which, if the mirror velocity were constant, would have a constant overlap of 71.5 feet. The actual mirror velocity is not constant because of the speeding up and slowing down of the mirror. A realistic representation of the mirror velocity versus time is very nearly a cosine curve during the active scan, as shown in Figure A-1. Since the mirror velocity is not constant, the amount of overlap is also variable, but is negligible for most applications of the data. Figure A-2 shows the variable overlap, exaggerated to illustrate this characteristic.

If the distance covered on the ground and the sweep time of the mirror are plotted for a constant mirror velocity and for a variable mirror velocity, the relationship between the two is similar to that shown in Figure A-3. The straight line shows a constant velocity of the mirror versus the distance covered on the ground. The curved line shows the actual variable velocity of the mirror versus the distance covered on the ground. The difference between the two lines indicates the corrections necessary to make points on the CCT reflect accurately the distance covered on the ground.

Figure A-4 shows a mirror velocity profile curve which plots the summation of the ground error versus the 185 km of ground covered. The maximum accumulated error is approximately ±400 meters (i.e., approximately 1300 feet, which is about 5 pixels). It should be noted that the mirror velocity profile curve shows the accumulated error at any point across the scan line. The accumulated error at 46.25 km is close to the maximum; however, at 92.5 km the accumulated error is zero. When interpreting the distance between two points on the ground corresponding to the distance between video

*This discussion is based on nominal spacecraft conditions (such as spacecraft altitude) and does not consider negligible perspective errors.



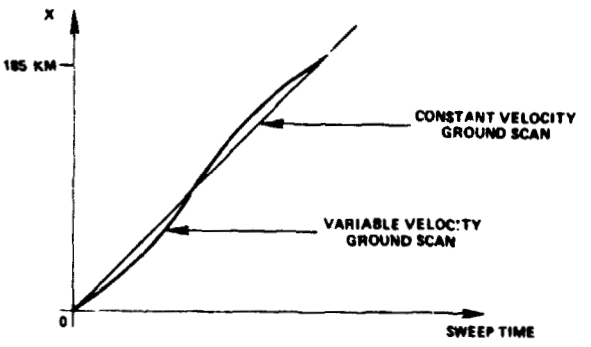
NOTE: Not drawn to scale

Figure A-1. Comparison of the Constant Mirror Velocity and the Variable Mirror Velocity

NOTE: 1. Pixels are represented by circles for ease of illustration; they are actually squares.

2. Not drawn to scale

Figure A-2. Overlay of Pixels, Corresponding to a Variable Mirror Velocity



Note: 1. X = the easterly scan of the ground

2. Not drawn to scale

Figure A-3. Comparison of Distance Covered on the Ground for a Constant Mirror Velocity and a Variable Mirror Velocity

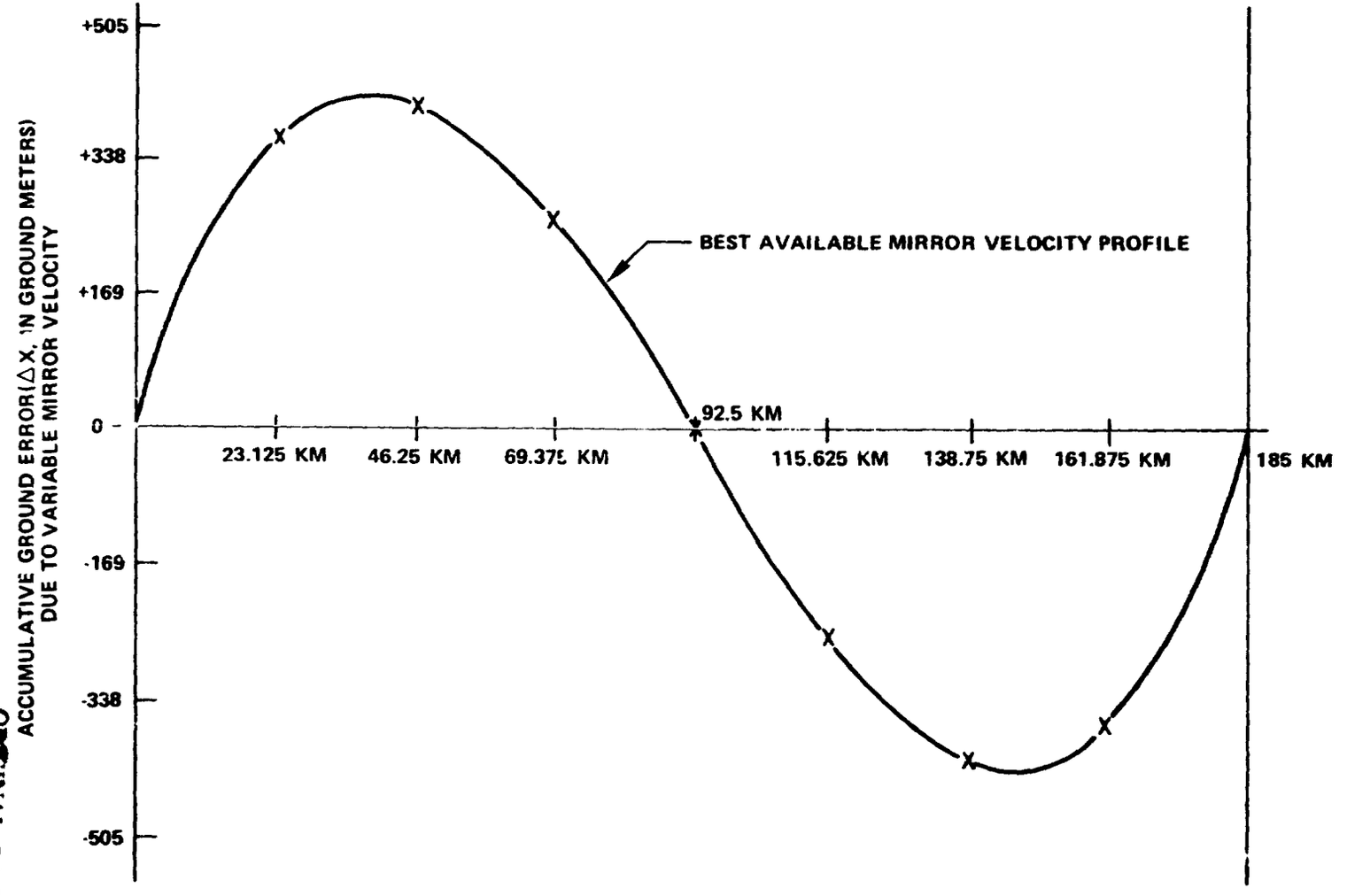


Figure A-4. Mirror Velocity Profile for the Active Mirror Scan

data bytes on the CCT, one must remember that the error accumulated from the beginning of the scan line to the point located at 46.25 km is approximately 400 meters. The distance represented by a quarter of a digital scan line is not 46.25 km; it is 46.25 km minus approximately 400 meters; whereas, half of the digital scan line corresponds to 92.5 km.

APPENDIX B

MAGNETIC TAPE PHYSICAL CHARACTERISTICS

Computer-compatible tapes (CCTs) are standard one-half-inch polyester-base magnetic tapes. The physical characteristics of CCTs are given in Figure B-1 and Table B-1.

There is one scene of digital imagery for each set of four CCTs, or on two merged CCTs. The external label on each tape contains the information shown in Figure B-2.

CCTs are available in two basic formats.

Nine-track, 800 bpi or 1600 bpi

For the nine-track CCT, the alphanumeric data are in EBCDIC and the video data are in binary.

Seven-track, 800 bpi

The seven-track CCT contains packed binary video data and packed binary EBCDIC alphanumeric data. The record layout and bit structure are identical to the layout and structure of the nine-track CCT. The standard product is a seven-track, 800-bpi CCT, but a seven-track, 556-bpi CCT may be ordered by special request. The format is the same as for the 800-bpi CCT.

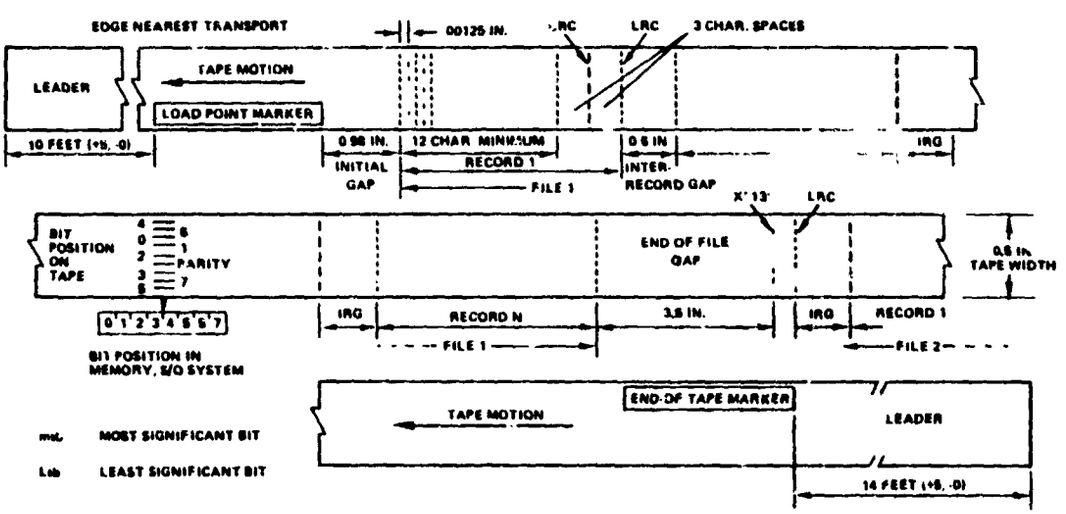


Figure B-1. Physical Spacing of Records on Tape

Table B-1.

CCT Operational Data Format Definitions

Tape Recording		
Tape:		0.5 inch wide; 2400 ft. long, 1.5 mil thick, mylar or polyester base.
Load Point Marker: (LPM)		Placed parallel to and not more than 1/32 inch from the edge of the tape nearest the operator when reel is mounted, providing a leader of at least 10 feet.
End of Tape Marker: (EOT)		Placed parallel to and not more than 1/32 inch from the edge of the tape nearest the tape unit when the tape is mounted, providing a leader of at least 14 feet.
Recording Method:		NRZ 1 (non-return to zero, change on ones).
7-track	Interchange code:	Video data, packed binary; Alphanumeric ID data in packed binary EBCDIC.
	Recording format:	7 channels, 6 information bits plus parity, packed binary.
	Recording density:	800 bpi is standard; 556 bpi by special request.
9-track	Interchange code:	Video data, binary; Alphanumeric ID data, EBCDIC.
	Recording format:	9 channels, 8 information bits plus parity, binary.
	Recording density:	800 bits per inch, or 1600 bits per inch.
Tape Records		
Data Records:		Records of logical data are separated by inter-record gap.
Record Size:		Minimum: 12 bytes; maximum: limited by computer memory.
Initial Gap: (IG)		0.94 inch after load point marker.
Inter-record Gap: (IRG)		0.60 +0.15, -.10 inch
Tape Mark (End of File, EOF):		3.5 inch, followed by one byte (x'13'), followed by a longitudinal check character (LRC) only.
Validity Checks		
Vertical:		Odd parity is used.
Longitudinal:		Longitudinal redundancy check (LRC), cyclic redundancy check (CRC) characters written automatically following data records.
Physical Spacing:		Refer to Figure B-1 for description.

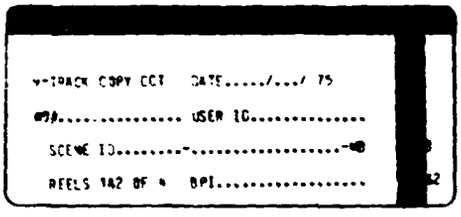


Figure B-2. External Tape Label

APPENDIX C

LINE LENGTH ADJUSTMENT

When the MSS video tape is processed in IIGS in the video-to-tape mode, a comparison is made while each scan line is being read to determine the maximum line length code (LLC) for the scene. The maximum LLC, referred to as Nmax, is entered by the operator and used by the digital subsystem (DS) to compute the adjusted line length.

To compute the adjusted line length, DS uses the Nmax from the APT and LLC, a code denoting the number of video data samples per uncorrected (raw) scan line, referred to as LLC raw, which is provided to the DS in the calibration data. In computing the adjusted line length, LLC raw is confined to boundaries as follows:

$$2650 < \text{LLC raw} \leq 3480$$

If LLC raw extends beyond these boundaries, DS uses the value of LLC raw from the previous scan line. Next, Nmax minus LLC raw is computed; if it is equal to zero, no line length corrections are made. LLA (adjusted line length) is converted to the smallest multiple of 24 which satisfies the following condition:

$$\text{LLA} > \text{Nmax} + 6$$

where 6 corresponds to the number of registration fill characters added to each interleaved scan line

or

$$\text{LLA} = 24n$$

where n = integer part of:

$$E = \frac{\text{Nmax} + 6 + 23}{24}$$

23/24 provides high roundoff.

The multiple of 24 is selected as the smallest integer which is divisible by both six and eight, the six representing six bytes maximum for spatial registration, the eight representing bytes for interleaving (two bytes per band, multiplied by four bands).

After calculating the LLA, a computation is made to determine the interval for interspersing synthetic bytes. To obtain equal line lengths, synthetic bytes are interspersed with data bytes at a specific interval. The value assigned to the synthetic byte is equal to the actual quantum level of the last video data byte immediately preceding the synthetic byte. The interval is calculated as follows:

$$\Delta = \frac{LLC}{LLA-(LLC+6)} \quad \text{(integer part only)}$$

This interval is set into a counter. The counter is decremented with each transfer of video data (bytes). When the counter reaches zero, the last data byte transferred is repeated. The counter is then reset and the process is repeated until the scan line is complete.

All deltas in the count sequence are the same with the exception of the initial deltas, which must be adjusted to correct for spectral band misregistration. As the data is transmitted from the sensor, each MSS band is spatially offset from the preceding band by two video data bytes (a function of sensor operation). Therefore, to register the video data on the CCT, Band 1 data is offset by six bytes, Band 2 by four bytes, and Band 3 by two bytes relative to Band 4. This is accomplished by adding registration fill characters of X'FF' data.

To adjust the delta for the initial count for each scan line, the quantity Δ_b is subtracted, where:

$$\Delta b = 8 - 2 * b$$

where b is the spectral band number; i.e.,

$$\Delta initial = \Delta - \Delta_b$$

APPENDIX D

RADIOMETRIC CALIBRATION

Figure D-1 shows the data flow through the initial image generating subsystem (IIGS) and the digital subsystem (DS) of the NASA Data Processing Facility. The MSS video data is entered into the DPPS where a high-density digital tape (HDDT) is made. The HDDT contains the uncalibrated data, line length code values for each scan line and the radiometric calibration wedge samples. The HDDT is the input to the DS. The DS reformats the data, calibrates the data and generates the CCT.

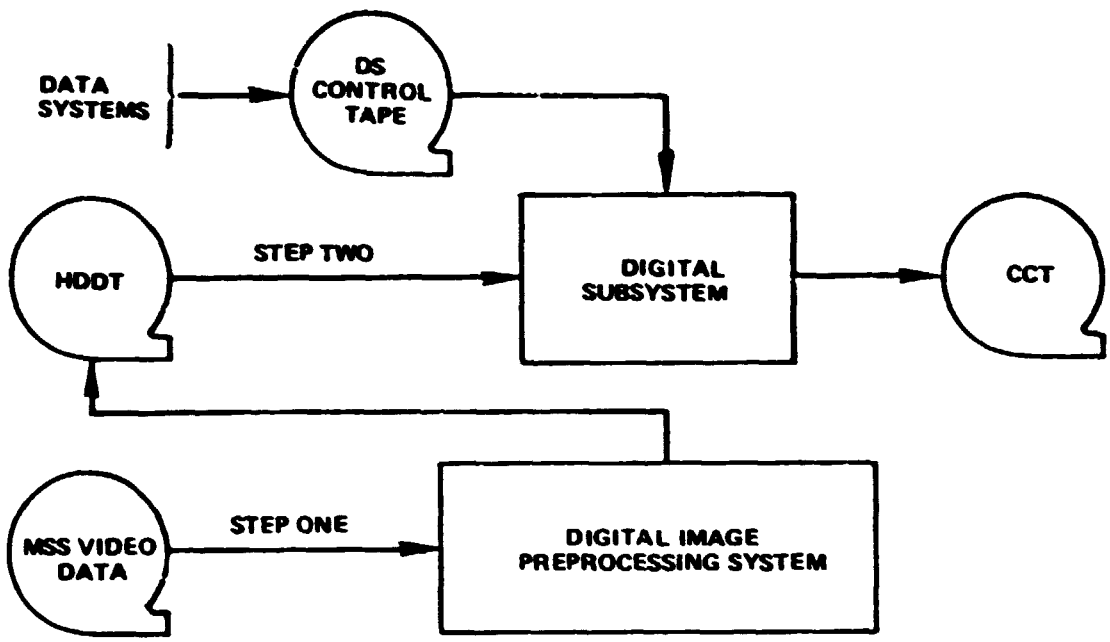


Figure D-1. Data Flow through IIGS and DS

Figure D-2 is a flowchart of the radiometric calibration procedure (used for the first three MSS bands; the fourth band is uncalibrated for Landsat-1) which takes place in the DS. A detailed explanation of the equations, calibration wedge word counts, maximum specified radiance and the sun calibration procedure is provided in the ERTS Data Users' Handbook. Note that the sun calibration is not used at present; the sun cal coefficient K_s is set equal to one.

The calibration data from the HDDT scan line record is entered into the system. At this point, either a compressed or decompressed mode is selected. Next, an estimate is made for $\hat{a}$ and $\hat{b}$ from the calibration data. The equations used in making this estimate are the following:

$$\left.\begin{aligned} \hat{a} &= \sum_{i=1}^{6} C_i V_i \\ \hat{b} &= \sum_{i=1}^{6} D_i V_i \end{aligned}\right\} \quad \text{Linear regression}$$

V_i is the input value of the cal wedge word i, and C_i and D_i are regression coefficients. See Tables D-1 through D-5 for the C_i's and D_i's. $\hat{a}$ and $\hat{b}$ are then filtered, yielding $\hat{a}_s$ and $\hat{b}_s$, which are referred to as the filtered offset and filtered gain respectively. The filter equations are as follows:

$$(\hat{a}_s)_n = \begin{cases} \hat{a}_n & \text{, for } n = 1 \\ (\hat{a}_s)_{n-1} + W_n^a \left[\hat{a}_n - (\hat{a}_s)_{n-1}\right] & \text{, for } n > 1 \end{cases}$$

and

$$(\hat{b}_s)_n = \begin{cases} \hat{b}_n & \text{, for } n = 1 \\ (\hat{b}_s)_{n-1} + W_n^b \left[\hat{b}_n - (\hat{b}_s)_{n-1}\right] & \text{, for } n > 1 \end{cases}$$

where

$$W_n^a = \begin{cases} 1/n, & \text{for } n \le N_a \\ 1/N_a, & \text{for } n > N_a \end{cases}$$

and

$$W_n^b = \begin{cases} 1/n, & \text{for } n \le N_b \\ 1/N_b, & \text{for } n > N_b \end{cases}$$

N_b is the control number for the gain filter. The present value for N_a and N_b is 32.

Finally, calibrated values are produced by applying the following equation:

$$\hat{U}_{s_n} = \frac{K_S}{M(\hat{b}_s)_n} \left[X(U) - (\hat{a}_s)_n \right] - A$$

K_S is the sun cal coefficient and U is the gray scale level (0 to 63). M and A are image dependent parameters used to minimize striping and are contained in the SIAT file.

The transformation X (U) may be the decompression transform or it may be the identity transform. Values of U_S are rounded to integers before being loaded into the look-up table.

NOTE:

The previous equations are applied once per sensor for each band on the odd mirror sweep (six scan lines per mirror sweep). A filtered gain and offset are saved for each sensor in each band in order to calibrate the even sweep.

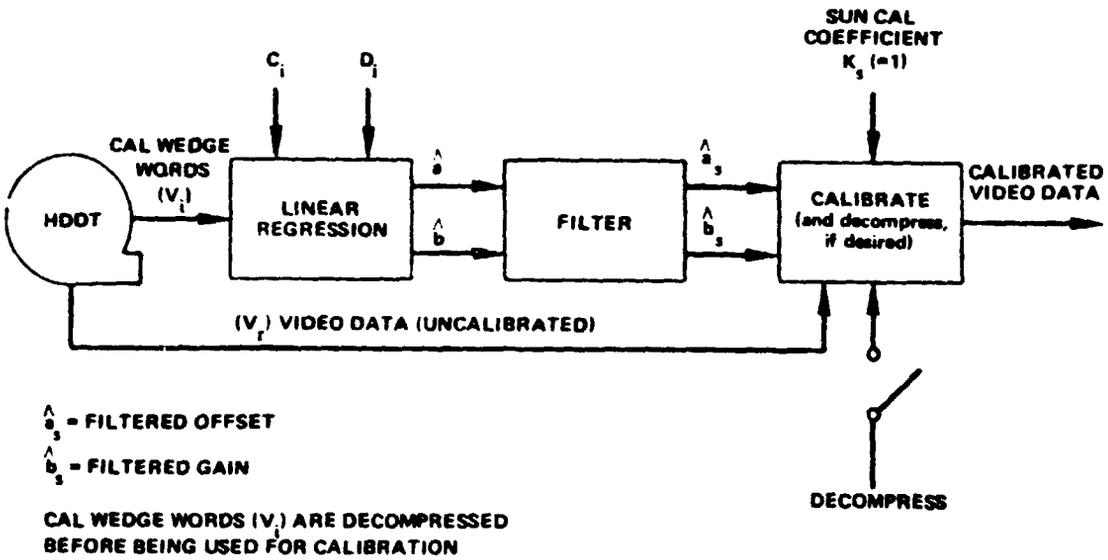


Figure D-2. DS Radiometric Calibration Flowchart

Table D-1

Landsat-1 Ci's and Di's - 9/5/75

LOW GAIN DECOMPRESSED

Sensor	D_1	C_1	D_2	C_2	D_3	C_3	D_4	C_4	D_5	C_5	D_6	C_6
Band 4												
1	1.036133	- .108398	.854736	- .065918	- .247559	.191650	- .352783	.214309	- .601807	.274658	- .688477	.294922
2	1.047363	- .138477	.862793	- .114258	- .251709	.332764	- .357422	.375244	- .606934	.475342	- .694092	.510254
3	1.116943	- .140137	.913574	- .084961	- .273926	.257061	- .383301	.266602	- .640869	.336426	- .732178	.361328
4	1.009521	- .131592	.826172	- .077393	- .250244	.240479	- .343877	.269775	- .578613	.337646	- .657471	.360840
5	1.096191	.110069	.894043	- .083740	- .273193	.246582	- .375906	.276611	- .625732	.346436	- .712158	.370850
6	1.111258	- .171387	.911751	- .102539	- .272217	.305664	- .382568	.343750	- .641846	.433105	- .731934	.464111
Band 5												
7	1.062500	- .108154	.754639	- .044922	- .293701	.170654	- .366943	.185791	- .537109	.220703	- .619385	.237793
8	1.057373	.211914	.765137	.093750	- .283936	- .330322	- .361572	- .361572	- .543701	- .435303	- .633057	- .471436
9	1.049805	- .195068	.750488	- .082764	- .287354	.307129	- .361328	.334717	- .533691	.399658	- .617432	.431152
10	1.077393	- .163818	.777100	- .071533	- .291016	.255859	- .369141	.279297	- .552246	.335937	- .641846	.363525
11	1.041992	- .125000	.744873	- .053711	- .284668	.192383	- .358154	.209961	- .530029	.250977	- .613770	.271240
12	1.092285	- .212646	.781250	- .093506	- .296143	.324219	- .374268	.354492	- .557861	.425293	- .647705	.460205
Band 6												
13	1.114652	.629883	.769043	.247070	.240479	- .331787	- .647949	-1.305176	- .703125	-1.365723	- .777100	-1.446777
14	1.104980	- .008057	.773437	- .003174	.259521	.093906	- .647705	.017090	- .706055	.018066	- .764424	.019043
15	1.116454	- .170654	.805664	- .070313	.273926	.085938	- .673828	.364746	- .735107	.382812	- .817383	.406982
16	1.285645	.382812	.902100	.153320	.30443	- .204590	- .755615	- .839355	- .823242	- .879883	- .913574	- .934082
17	1.256104	- .166016	.873535	- .064697	.254668	.091064	- .733643	.360840	- .797607	.377930	- .882812	.400391
18	1.157227	- .175049	.808594	- .070068	.270752	.092529	- .677490	.379639	- .737793	.397949	- .818848	.422607
Band 7												
19	1.533203	- .180664	1.105713	- .080994	.583496	.034180	- .984863	.389893	-1.079834	.411377	-1.157471	.428955
20	1.715088	- .181396	1.236816	- .080420	.652832	.032959	-1.101562	.392090	-1.207764	.413818	-1.294922	.431641
21	1.628174	- .181885	1.1691	- .083496	.610840	.035645	-1.043701	.389893	-1.142090	.411133	-1.222656	.428223
22	1.674512	- .177490	1.209961	- .084717	.713652	.030029	-1.212646	.389160	-1.336426	.411865	-1.436477	.430664
23	1.934570	- .171631	1.399902	- .078125	.744385	.036377	-1.215605	.384521	-1.366943	.405518	-1.466309	.423096
24	1.704102	- .170898	1.21[illegible]	- .074707	.629395	.04174[illegible]	-1.090088	.382568	-1.189941	.402344	-1.271484	.418701

Table D-2
Landsat-1 Ci's and Di's - 9/5/75

HIGH GAIN DECOMPRESSED

Sensor	D_1	C_1	D_2	C_2	D_3	C_3	D_4	C_4	D_5	C_5	D_6	C_6
Band 4												
1	.000000	.000000	.000000	.000000	1.712646	- .410889	.911133	- .086914	- .981689	.674487	-1.642578	.945557
2	.000000	.000000	.000000	.000000	1.689697	- .525391	.898193	- .113037	- .967773	.659131	-1.620117	1.198730
3	.000000	.000000	.000000	.000000	1.655169	- .408936	.987061	- .103027	-1.056350	.617157	-1.783936	.872803
4	.000000	.000000	.000000	.000000	1.625488	- .482715	.955957	- .058350	- .932861	.462891	-1.548584	.642578
5	.000000	.000000	.000000	.000000	1.639844	- .396963	.972656	- .092529	-1.052002	.594971	-1.760498	.935693
6	.000000	.000000	.000000	.000000	1.737324	- .354492	.930664	- .076660	-1.007080	.574707	-1.681152	.801270
Band 5												
7	.000000	.000000	.000000	.000000	1.911377	- .573730	1.039062	- .200195	- .985352	.666504	-1.965088	1.055937
8	.000000	.000000	.000000	.000000	1.863281	-1.101318	1.022461	- .377441	- .958008	1.327637	-1.927490	2.162354
9	.000000	.000000	.000000	.000000	1.852783	- .517578	1.010.42	- .179443	- .954102	.610352	-1.908936	.993652
10	.000000	.000000	.000000	.000000	1.929688	- .952881	1.057129	- .328125	- .992432	1.139893	-1.994385	1.857178
11	.000000	.000000	.000000	.000000	1.883301	- .509277	1.029297	- .180420	- .968506	.588379	-1.944092	.964111
12	.000000	.000000	.000000	.000000	1.875244	- .440918	1.027832	- .156982	- .963135	.510010	-1.940186	.937646

Table D-3
Landsat-2 Ci's and Di's - 9/5/75

HIGH GAIN DECOMPRESSED

Sensor	D_1	C_1	D_2	C_2	D_3	C_3	D_4	C_4	D_5	C_5	D_6	C_6
Band 4												
1	.930420	- .229248	.518555	- .053955	.272461	.050781	- .231934	.265a25	- .612793	.427734	- .875732	.539795
2	1.061279	- .229248	.585205	- .051514	.311523	.050537	- .260254	.263916	- .697998	.427246	- .999023	.539795
3	.822266	- .225586	.496826	- .070313	.246094	.049072	- .200928	.262695	- .566406	.437256	- .797119	.547363
4	.867920	- .220459	.528320	- .069092	.264404	.048584	- .212402	.261475	- .600098	.434814	- .847412	.545166
5	.919189	- .222900	.526611	- .056396	.286133	.046410	- .225586	.262457	- .630859	.434326	- .874756	.537598
6	.892334	- .225098	.511475	- .057861	.268799	.048584	- .218262	.262695	- .609619	.434570	- .84399.	.537598
Band 5												
7	1.280273	- .454102	.762451	- .202881	.225342	.057373	- .295654	.310059	- .728271	.520020	-1.243408	.769775
8	1.460693	- .449219	.905518	- .215088	.304443	.038330	- .424805	.345947	- .824707	.514648	-1.420410	.765869
9	1.158203	- .482422	.685303	- .217285	.218750	.043945	- .297363	.333496	- .633301	.521729	-1.170859	.800781
10	1.156738	- .444824	.703857	- .205322	.216553	.052246	- .303467	.327148	- .638184	.504395	-1.134521	.766846
11	1.137939	- .450195	.690918	- .207764	.208252	.053711	- .286865	.322266	- .634521	.510742	-1.111990	.771484
12	1.321289	- .502197	.709527	- .233398	.200439	.065186	- .447266	.393311	- .651855	.496826	-1.212402	.780762

Table D-4

Landsat-2 Ci's and Di's - 9/5/75

LOW GAIN DECOMPRESSED

Sensor	D_1	C_1	D_2	C_2	D_3	3	D_4	C_4	D_5	C_5	D_6	C_6
Band 4												
1	1.124023	- .120850	.710205	- .046113	.031738	.076416	- .238770	.125244	- .658203	.201172	- .968018	.257324
2	1.268066	- .158691	.786377	- .057861	.040283	.098145	- .269287	.163086	- .734131	.260498	-1.090332	.334961
3	1.068379	- .174561	.720459	- .077148	.045166	.101562	- .217646	.169922	- .654053	.286865	- .986572	.375000
4	1.113770	- .108213	.760010	- .078613	.050537	.100342	- .211425	.166992	- .684082	.286621	-1.027832	.373779
5	1.145996	- .194092	.736572	- .078369	.051025	.114990	- .224121	.192871	- .680176	.322021	-1.028076	.420410
6	1.114502	- .151123	.723877	- .062256	.039307	.093018	- .229248	.154053	- .691865	.252441	- .985596	.326172
Band 5												
7	1.049561	- .053711	.735107	- .025635	.073975	.032715	- .256592	.062256	- .656494	.097656	- .944824	.122291
8	1.221924	- .089600	.872559	- .045898	.036621	.058594	- .270367	.098145	- .761963	.158936	-1.090820	.200195
9	.979004	- .088379	.697754	- .045898	.080566	.047119	- .230713	.094482	- .615479	.152832	- .910400	.197266
10	.978027	- .083740	.706299	- .042480	074219	.052002	- .237305	.077881	- .614502	.155273	- .832520	.196730
11	.938721	- .094727	.672607	- .048828	.065918	.055176	- .231689	.106445	- .586914	.167725	- .858643	.214600
12	.975586	- .149902	.689941	- .074707	.058105	.090332	- .236037	.158213	- .604980	.264648	- .879883	.336670
Band 6												
13	1.194580	- .176758	.831787	- .090332	.018555	.103027	- .278809	.174316	- .753662	.287354	-1.011475	.348877
14	1.132324	- .106934	.786602	- .051758	.022949	.060059	- .251953	.101807	- .713379	.171387	- .955811	.207764
15	1.133545	- .135010	.787598	- .069824	.025146	.072998	- .250723	.123047	- .728271	.214844	- .976807	.261719
16	1.043213	- .103027	.740967	- .055176	.020752	.058594	- .219727	.096680	- .675293	.168701	- .908936	.205811
17	1.046875	- .120605	.750244	- .065430	.011230	.072021	- .224609	.115967	- .673340	.199463	- .909180	.243652
18	1.156250	- .064941	.782959	- .031006	.014160	.038574	- .255127	.062988	- .724854	.105713	- .973145	.128418
Band 7												
19	1.763672	- .473877	1.112793	- .219971	.352539	.075928	- .383057	.363281	-1.077881	.634277	-1.767334	.903320
20	1.740234	- .709473	1.126709	- .353760	.383301	.076416	- .348389	.580244	-1.077148	.922363	-1.823730	1.354980
21	1.468262	- .490479	.944336	- .245361	.330078	.041504	- .266113	.321045	- .898926	.616943	-1.576660	.934570
22	1.533936	- .644775	1.005615	- .333008	.340576	.059570	- .281494	.427490	- .953857	.824463	-1.644287	1.232422
23	1.455811	- .363525	.942383	- .180176	.322998	.039795	- .280762	.256104	- .900635	.477295	-1.539063	.704834
24	1.612305	- .535400	1.044922	- .267916	.355539	.066895	- .296143	.377686	-1.002197	.713867	-1.714844	1.056885

Table D-5

Landsat-3 Ci's and Di's - Not available at printing

APPENDIX E

DECOMPRESSION TABLES
USED BY DIGITAL SUBSYSTEM PRIOR TO CALIBRATION

The following tables are used for decompressing the video data from Bands 4, 5 and 6. Band 7 is linear and requires no decompression.

The values of the compressed video data vary from 0 to 63; after decompression, the video data values vary from 0 to 127. The decompressed values, gains and offsets are used to determine the calibrated values of the video data. To reverse the process and obtain compressed values from the decompressed values of the CCT, the user must have the gain and offset values in addition to the values in the decompression table.

MSS Bands 4 and 6, Landsat-1

Input	Output	Input	Output	Input	Output
0	0	17	17	28	34
1	1	18	18		35*
2,3	2	19	19	29	36
4	3		20*		37*
5	4	20	21	30	38
6	5	21	22		39*
7	6		23*	31	40
8	7	22	24		41*
9	8	23	25	32	42
10	9		26*	33	43
11	10	24	27		44*
12	11		28*	34	45
13	12	25	29		46*
14	13	26	30	35	47
15	14		31*		48*
	15*	27	32	36	49
16	16		33*		50*

*Prior to calibration these quantum levels are not used. After calibration (individual detector offset and gain adjustment) different quantum levels may be used, while others are unused.

MSS Bands 4 and 6, Landsat-1

Input	Output	Input	Output	Input	Output
37	51		76*		102*
	52*		77*		103*
38	53	47	78	56	104
	54*		79*		105*
	55*		80*	57	106
39	56	48	81		107*
	57*		82*		108*
40	58	49	83	58	109
	59*		84*		110*
	60*		85*		111*
41	61	50	86	59	112
	62*		87*		113*
42	63		88*		114*
	64*	51	89	60	115
	65*		90*		116*
43	66		91*		117*
	67*	52	92	61	118
	68*		93*		119*
44	69		94*		120*
	70*	53	95	62	121
	71*		96*		122*
45	72		97*		123*
	73*	54	98	63	124
	74*		99*		125*
46	75		100*		126*
		55	101		127*

*Prior to calibration these quantum levels are not used. After calibration (individual detector offset and gain adjustment) different quantum levels may be used, while others are unused.

MSS Band 5, Landsat-1

Input	Output	Input	Output	Input	Output
0	0	26	30	41	60
1	1		31*		61*
2,3	2	27	32		62*
4	3		33*	42	63
5	4	28	34		64*
6	5		35*		65*
7	6	29	36	43	66
8	7		37*		67*
9	8	30	38		68*
10	9	31	39	44	69
11	10		40*		70*
12	11	32	41	45	71
13	12		42*		72*
14	13	33	43		73*
15	14		44*	46	74
	15*	34	45		75*
16	16		46*		76*
17	17	35	47	47	77
18	18		48*		78*
19	19	36	49		79*
	20*		50*	48	80
20	21	37	51		81*
21	22		52*		82*
22	23	38	53	49	83
	24*	39	54		84*
23	25		55*		85*
	26*		56*	50	86
24	27		57*		87*
25	28	40	58	51	88
	29*		59*		89*
					90*

*Prior to calibration these quantum levels are not used. After calibration (individual detector offset and gain adjustment) different quantum levels may be used, while others are unused.

MSS Band 5, Landsat-1

Input	Output	Input	Output	Input	Output
52	91		103*	60	115
	92*	56	104		116*
	93*		105*	61	117
53	94		106*		118*
	95*	57	107		119*
	96*		108*	62	120
54	97	58	109		121*
	98*		110*	63	122
	99*		111*		123*
55	100	59	112		124*
	101*		113*		125*
	102*		114*		126*
					127*

MSS Band 7, Landsat-1

Data from MSS Band 7 are not decompressed.

*Prior to calibration these quantum levels are not used. After calibration (individual detector offset and gain adjustment) different quantum levels may be used, while others are unused.

MSS Bands 4 and 6, Landsat-2

Input	Output	Input	Output	Input	Output
0	0		42*		85*
1	1	32	43		86*
2	1		44*	49	87
3	2	33	45		88*
4	3		46*		89*
5	4	34	47	50	90
6	5		48*		91*
7	6	35	49	51	92
8	7		50*		93*
9	8	36	51		94*
10	9		52*	52	95
11	10	37	53		96*
12	11		54*		97*
13	12	38	55	53	98
14	13		56*		99*
	14*		57*		100*
15	15	39	58	54	101
16	16		59*		102*
17	17	40	60		103*
18	18		61*	55	104
	19*		62*		105*
19	20	41	63		106*
	21*		64*		107*
20	22		65*	56	108
21	23	42	66		109*
	24*		67*		110*
22	25	43	68	57	111
23	26		69*		112*
	27*		70*		113*
24	28	44	71	58	114
	29*		72*		115*
25	30		73*		116*
	31*	45	74	59	117
26	32		75*		118*
	33*		76*		119*
27	34	46	77	60	120
28	35		78*		121*
	36*		79*		122*
29	37	47	80	61	123
	38*		81*		124*
30	39		82*	62	125
	40*		83*		126*
31	41	48	84	63	127

*Prior to calibration these quantum levels are not used. After calibration (individual detector offset and gain adjustment) different quantum levels may be used, while others are unused.

MSS Band 5, Landsat-2

Input	Output	Input	Output	Input	Output
0	0	25	30	40	60
1	1		31*		61*
2	2	26	32		62*
3	3		33*	41	63
4	4	27	34		64*
5	5	28	35		65*
6	6		36*	42	66
7	7	29	37		67*
8	8		38*		68*
9	9	30	39	43	69
10	10		40*		70*
11	11	31	41		71*
12	12	32	42	44	72
13	13		43*		73*
14	14		44*	45	74
15	15	33	45		75*
	16*		46*		76*
16	17	34	47	46	77
17	18		48*		78*
18	19	35	49		79*
19	20		50*	47	80
	21*		51*		81*
20	22	36	52		82*
21	23		53*	48	83
	24*	37	54		84*
22	25		55*		85*
23	26	38	56	49	86
	27*		57*		87*
24	28	39	58		88*
	29*		59*	50	89
					90*

*Prior to calibration these quantum levels are not used. After calibration (individual detector offset and gain adjustment) different quantum levels may be used, while others are unused.

MSS Band 5, Landsat-2

Input	Output	Input	Output	Input	Output
	91*		103*		115*
51	92	55	104	59	116
	93*		105*		117*
	94*		106*		118*
52	95	56	107	60	119
	96*		108*		120*
	97*		109*		121*
53	98	57	110	61	122
	99*		111*		123*
	100*		112*		124*
54	101	58	113	62	125
	102*		114*		126*
				63	127

MSS Band 7, Landsat-2

Data from MSS Band 7 are not decompressed.

*Prior to calibration these quantum levels are not used. After calibration (individual detector offset and gain adjustment) different quantum levels may be used, while others are unused.

MSS Bands 4 and 6, Landsat-3

Input	Output	Input	Output	Input	Output	Input	Output
0	0	26	31		*63		*95
1	1		*32		*64		*96
2	2	27	33	42	65	53	97
3	3		*34		*66		*98
4	4	28	35		*67		*99
5	5		*36	43	68	54	100
6	6	29	37		*69		*101
7	6		*38		*70		*102
8	7	30	39	44	71	55	103
9	8		*40		*72		*104
10	9	31	41		*73		*105
11	10		*42	45	74	56	106
	*11	32	43		*75		*107
12	12		*44		*76		*108
13	13	33	45	46	77	57	109
14	14		*46		*78		*110
15	15	34	47	47	79		*111
	*16		*48		*80	58	112
16	17	35	49		*81		*113
17	18		*50	48	82		*114
18	19	36	51		*83	59	115
19	20		*52		*84		*116
	*21	37	53	49	85		*117
20	22		*54		*86	60	118
21	23	38	55		*87		*119
	*24		*56	50	88		*120
22	25	39	57		*89	61	121
	*26		*58		*90		*122
23	27		*59	51	91		*123
						62	124
24	28	40	60		*92		*125
	*29		*61		*93		*126
25	30	41	62	52	94	63	127

*Prior to calibration these quantum levels are not used. After calibration (individual detector offset and gain adjustment) different quantum levels may be used, while others are unused.

MSS Band 5, Landsat-3

Input	Output	Input	Output	Input	Output	Input	Output*
0	0		*33	12	66		*99
1	1	27	34		*67		*100
2	2		*35		*68	54	101
3	3	28	36	43	69		*102
4	4		*37		*70		*103
5	5	29	38	14	71	55	104
6	6		*39		*72		*105
7	7	30	40		*73		*106
8	8	31	41	15	74	56	107
9	9		*42		*75		*108
10	10	32	43		*76		*109
11	11		*44	46	77	57	110
12	12	33	45		*78		*111
13	13		*46		*79		*112
14	14	34	47	47	80	58	113
	*15		*48		*81		*114
15	16	35	49		*82		*115
16	17		*50	48	83	59	116
17	18	36	51		*84		*117
18	19		*52		*85	60	118
	*20	37	53	49	86		*119
19	21		*54		*87		*120
20	22	38	55		*88	61	121
21	23		*56	50	89		*122
	*24		*57		*90		*123
22	25	39	58		*91	62	124
	*26		*59	51	92		*125
23	27	40	60		*93		
24	28		*61		*94		*126
	*29		*62	52	95		
25	30	41	63		*96	63	127
	*31		*64		*97		
26	32		*65	53	98		

*Prior to calibration these quantum levels are not used. After calibration (individual detector offset and gain adjustment) different quantum levels may be used, while others are unused.

MSS Band 7, Landsat-3

Data from MSS Band 7 are not decompressed.

APPENDIX F

TICK MARK REFERENCE SYSTEM

The Bulk MSS film image is used in establishing the tick mark reference system. The scene on a 70-mm film image is 55 mm in the X direction and 53 mm in the Y direction. The area represented by the scene is 185 km by 178.36 km; this scene consists of 2256 scan lines.

The tick mark reference system has been chosen so that the origin is at the format center. The corners of the tick mark reference system are designated A (1/2, -1/2), B (-1/2, -1/2), C (1/2, 1/2) and D (-1/2, 1/2). See Figure F-1.

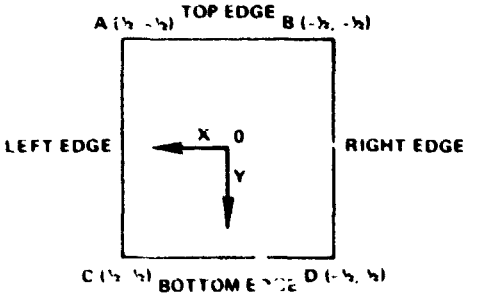


Figure F-1. Tick Mark Reference System

The value that locates the tick marks along the edges is, therefore, given in terms of a 16-bit binary integer fraction with the binary point to the left of bit position 0.

It should be noted that the scene on the Bulk MSS CCT contains 2340 scan lines, equating to 2256 scan lines for the film image, plus 42 scan lines of data preceding the film image and 42 scan lines following the film image as shown in Figure F-2.

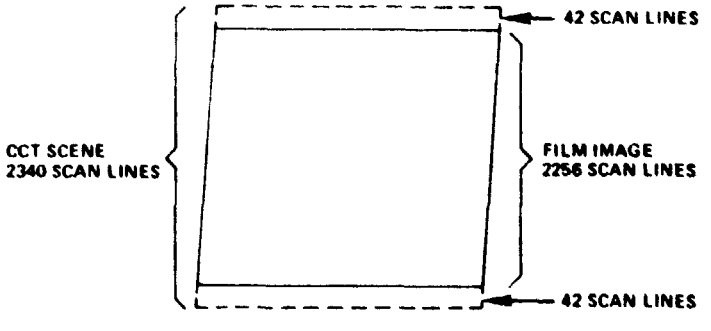


Figure F-2. CCT and Film Image Comparison

APPENDIX G

CONVERSION TABLES

CONVERSION TABLE: BINARY/OCTAL/DECIMAL/HEXADECIMAL

Binary	Octal	Decimal	Hexadecimal
00000000	0	0	0
00000001	1	1	1
00000010	2	2	2
00000011	3	3	3
00000100	4	4	4
00000101	5	5	5
00000110	6	6	6
00000111	7	7	7
00001000	10	8	8
00001001	11	9	9
00001010	12	10	A
00001011	13	11	B
00001100	14	12	C
00001101	15	13	D
00001110	16	14	E
00001111	17	15	F
00010000	20	16	10
00010001	21	17	11
00010010	22	18	12
00010011	23	19	13
00010100	24	20	14
00010101	25	21	15
00010110	26	22	16
00010111	27	23	17
00011000	30	24	18
00011001	31	25	19
00011010	32	26	1A
00011011	33	27	1B
00011100	34	28	1C
00011101	35	29	1D
00011110	36	30	1E
00011111	37	31	1F
00100000	40	32	20
00100001	41	33	21
00100010	42	34	22
00100011	43	35	23
00100100	44	36	24

Binary	Octal	Decimal	Hexadecimal
00100101	45	37	25
00100110	46	38	26
00100111	47	39	27
00101000	50	40	28
00101001	51	41	29
00101010	52	42	2A
00101011	53	43	2B
00101100	54	44	2C
00101101	55	45	2D
00101110	56	46	2E
00101111	57	47	2F
00110000	60	48	30
00110001	61	49	31
00110010	62	50	32
00110011	63	51	33
00110100	64	52	34
00110101	65	53	35
00110110	66	54	36
00110111	67	55	37
00111000	70	56	38
00111001	71	57	39
00111010	72	58	3A
00111011	73	59	3B
00111100	74	60	3C
00111101	75	61	3D
00111110	76	62	3E
00111111	77	63	3F
01000000	100	64	40
01000001	101	65	41
01000010	102	66	42
01000011	103	67	43
01000100	104	68	44
01000101	105	69	45
01000110	106	70	46
01000111	107	71	47
01001000	110	72	48
01001001	111	73	49
01001010	112	74	4A
01001011	113	75	4B

Binary	Octal	Decimal	Hexadecimal
01001100	114	76	4C
01001101	115	77	4D
01001110	116	78	4E
01001111	117	79	4F
01010000	120	80	50
01010001	121	81	51
01010010	122	82	52
01010011	123	83	53
01010100	124	84	54
01010101	125	85	55
01010110	126	86	56
01010111	127	87	57
01011000	130	88	58
01011001	131	89	59
01011010	132	90	5A
01011011	133	91	5B
01011100	134	92	5C
01011101	135	93	5D
01011110	136	94	5E
01011111	137	95	5F
01100000	140	96	60
01100001	141	97	61
01100010	142	98	62
01100011	143	99	63
01100100	144	100	64
01100101	145	101	65
01100110	146	102	66
01100111	147	103	67
01101000	150	104	68
01101001	151	105	69
01101010	152	106	6A
01101011	153	107	6B
01101100	154	108	6C
01101101	155	109	6D
01101110	156	110	6E
01101111	157	111	6F
01110000	160	112	70
01110001	161	113	71
01110010	162	114	72

Binary	Octal	Decimal	Hexadecimal
01110011	163	115	73
01110100	164	116	74
01110101	165	117	75
01110110	166	118	76
01110111	167	119	77
01111000	170	120	78
01111001	171	121	79
01111010	172	122	7A
01111011	173	123	7B
01111100	174	124	7C
01111101	175	125	7D
01111110	176	126	7E
01111111	177	127	7F

APPENDIX G (continued)

CONVERSION TABLE: HEXADECIMAL - DECIMAL FRACTION

Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal
00 00 00 00	00000 00000	40 00 00 00	25000 00000	80 00 00 00	50000 00000	C0 00 00 00	.75000 00000
.01 00 00 00	00390 62500	41 00 00 00	25390 62500	.81 00 00 00	50390 62500	C1 00 00 00	.75390 62500
.02 00 00 00	00781 25000	42 00 00 00	25781 25000	.82 00 00 00	.50781 25000	.C2 00 00 00	.75781 25000
.03 00 00 00	01171 87500	43 00 00 00	26171 87500	.83 00 00 00	51171 87500	.C3 00 00 00	.76171 87500
04 00 00 00	01562 50000	44 00 00 00	26562 50000	.84 00 00 00	51562 50000	C4 00 00 00	.76562 50000
.05 00 00 00	01953 12500	45 00 00 00	26953 12500	85 00 00 00	51953 12500	.C5 00 00 00	.76953 12500
.06 00 00 00	.02343 75000	46 00 00 00	27343 75000	.86 00 00 00	52343 75000	.C6 00 00 00	.77343 75000
.07 00 00 00	02734 37500	47 00 00 00	27734 37500	.87 00 00 00	52734 37500	C7 00 00 00	.77734 37500
.08 00 00 00	03125 00000	.48 00 00 00	28125 00000	.88 00 00 00	.53125 00000	.C8 00 00 00	.78125 00000
09 00 00 00	.03515 62500	49 00 00 00	.28515 62500	.89 00 00 00	.53515 62500	.C9 00 00 00	.78515 62500
0A 00 00 00	03906 25000	4A 00 00 00	28906 25000	8A 00 00 00	53906 25000	.CA 00 00 00	.78906 25000
.0B 00 00 00	.04296 87500	4B 00 00 00	29296 87500	8B 00 00 00	54296 87500	.CB 00 00 00	.79296 87500
0C 00 00 00	04687 50000	4C 00 00 00	29687 50000	8C 00 00 00	54687 50000	CC 00 00 00	79687 50000
0D 00 00 00	05078 12500	4D 00 00 00	30078 12500	8D 00 00 00	55078 12500	.CD 00 00 00	.80078 12500
0E 00 00 00	.05468 75000	4E 00 00 00	30468 75000	8E 00 00 00	55468 75000	CE 00 00 00	80468 75000
0F 00 00 00	.05859 37500	4F 00 00 00	30859 37500	8F 00 00 00	85859 37500	CF 00 00 00	.80859 37500
10 00 00 00	06250 00000	50 00 00 00	31250 00000	90 00 00 00	56250 00000	D0 00 00 00	.81250 00000
.11 00 00 00	06640 62500	51 00 00 00	31640 62500	91 00 00 00	.56640 62500	D1 00 00 00	.81640 62500
12 00 00 00	07031 25000	52 00 00 00	32031 25000	92 00 00 00	57031 25000	D2 00 00 00	.82031 25000
13 00 00 00	07421 87500	53 00 00 00	32421 87500	93 00 00 00	57421 87500	D3 00 00 00	.82421 87500
14 00 00 00	07812 50000	54 00 00 00	32812 50000	94 00 00 00	57812 50000	D4 00 00 00	82812 50000
15 00 00 00	08203 12500	55 00 00 00	33203 12500	95 00 00 00	58203 12500	D5 00 00 00	83203 12500
16 00 00 00	08593 75000	56 00 00 00	33593 75000	96 00 00 00	58593 75000	D6 00 00 00	83593 75000
17 00 00 00	08984 37500	57 00 00 00	33984 37500	97 00 00 00	58984 37500	D7 00 00 00	83984 37500
18 00 00 00	09375 00000	58 00 00 00	34375 00000	.98 00 00 00	59375 00000	.D8 00 00 00	.84375 00000
19 00 00 00	09765 62500	59 00 00 00	34765 62500	99 00 00 00	59765 62500	.D9 00 00 00	.84765 62500
1A 00 00 00	10156 25000	5A 00 00 00	35156 25000	9A 00 00 00	60156 25000	.DA 00 00 00	.85156 25000
1B 00 00 00	10546 87500	5B 00 00 00	35546 87500	9B 00 00 00	60546 87500	.DB 00 00 00	.85546 87500
1C 00 00 00	10937 50000	5C 00 00 00	35937 50000	.9C 00 00 00	60937 50000	.DC 00 00 00	.85937 50000
1D 00 00 00	11328 12500	5D 00 00 00	36328 12500	.9D 00 00 00	61328 12500	.DD 00 00 00	.86328 12500
1E 00 00 00	11718 75000	5E 00 00 00	36718 75000	9E 00 00 00	61718 75000	DE 00 00 00	86718 75000
1F 00 00 00	12109 37500	5F 00 00 00	37109 37500	9F 00 00 00	.62109 37500	DF 00 00 00	87109 37500
.20 00 00 00	12500 00000	60 00 00 00	37500 00000	A0 00 00 00	62500 00000	.E0 00 00 00	.87500 00000
21 00 00 00	12890 62500	61 00 00 00	37890 62500	.A1 00 00 00	62890 62500	.E1 00 00 00	.87890 62500
22 00 00 00	13281 25000	62 00 00 00	38281 25000	A2 00 00 00	63281 25000	.E2 00 00 00	.88281 25000
23 00 00 00	13671 87500	A3 00 00 00	38671 87500	.A3 00 00 00	.63671 87500	.E3 00 00 00	88671 87500
24 00 00 00	14062 50000	64 00 00 00	39062 50000	A4 00 00 00	64062 50000	E4 00 00 00	89062 50000
25 00 00 00	14453 12500	65 00 00 00	39453 12500	A5 00 00 00	64453 12500	E5 00 00 00	89453 12500
26 00 00 00	14843 75000	66 00 00 00	39343 75000	A6 00 00 00	64843 75000	.E6 00 00 00	.89643 75000
27 00 00 00	15234 37500	67 00 00 00	40234 37500	A7 00 00 00	65234 37500	E7 00 00 00	90234 37500
28 00 00 00	15625 00000	68 00 00 00	40625 00000	A8 00 00 00	.65625 00000	.E8 00 00 00	.90625 00000
29 00 00 00	16015 62500	69 00 00 00	410.5 62500	A9 00 00 00	.66015 62500	E9 00 00 00	91015 62500
2A 00 00 00	16406 25000	6A 00 00 00	41406 25000	AA 00 00 00	66406 25000	.EA 00 00 00	.91406 25000
2B 00 00 00	16796 87500	6B 00 00 00	41796 87500	AB 00 00 00	66796 87500	EB 00 00 00	.91796 87500
2C 00 00 00	17187 50000	6C 00 00 00	42187 50000	AC 00 00 00	67187 50000	EC 00 00 00	92187 50000
2D 00 00 00	17578 12500	6D 00 00 00	42578 12500	AD 00 00 00	67578 12500	ED 00 00 00	92578 12500
2E 00 00 00	17968 75000	6E 00 00 00	42968 75000	AE 00 00 00	67968 75000	.EE 00 00 00	.92968 75000
2F 00 00 00	18359 37500	6F 00 00 00	43359 37500	AF 00 00 00	68359 37500	.EF 00 00 00	.93359 37500
30 00 00 00	18750 00000	70 00 00 00	.43750 00000	B0 00 00 00	.68750 00000	F0 00 00 00	.93750 00000
31 00 00 00	19140 62500	71 00 00 00	44140 62500	B1 00 00 00	.69140 62500	.F1 00 00 00	.94140 62500
32 00 00 00	19531 25000	72 00 00 00	44531 25000	B2 00 00 00	.69531 25000	F2 00 00 00	.94531 25000
33 00 00 00	19921 87500	73 00 00 00	44921 87500	B3 00 00 00	69921 87500	.F3 00 00 00	.94921 87500
34 00 00 00	20312 50000	74 00 00 00	45312 50000	B4 00 00 00	70312 50000	F4 00 00 00	.95312 50000
35 00 00 00	20703 12500	75 00 00 00	45703 12500	B5 00 00 00	70703 12500	F5 00 00 00	.95703 12500
36 00 00 00	21093 75000	76 00 00 00	46093 75000	B6 00 00 00	71093 75000	F6 00 00 00	96093 75000
37 00 00 00	.21484 37500	77 00 00 00	46484 37500	B7 00 00 00	.71484 37500	.F7 00 00 00	.96484 37500
38 00 00 00	21875 00000	.78 00 00 00	46875 00000	B8 00 00 00	.71875 00000	F8 00 00 00	.96875 00000
39 00 00 00	22265 62500	79 00 00 00	47265 62500	B9 00 00 00	.72265 62500	.F9 00 00 00	.97265 62500
3A 00 00 00	22656 25000	7A 00 00 00	47656 25000	BA 00 00 00	72656 25000	FA 00 00 00	.97656 25000
3B 00 00 00	23046 87500	7B 00 00 00	48046 87500	BB 00 00 00	.73046 87500	.FB 00 00 00	98046 87500
3C 00 00 00	50000	7C 00 00 00	48437 50000	BC 00 00 00	.73437 50000	.FC 00 00 00	98437 50000
3D 00 00 00	23828 12500	7D 00 00 00	48828 12500	BD 00 00 00	.73828 12500	.FD 00 00 00	98828 12500
3E 00 00 00	24218 75000	7E 00 00 00	49218 75000	BE 00 00 00	74218 75000	.FE 00 00 00	.99218 75000
3F 00 00 00	24609 37500	7F 00 00 00	49609 37500	.BF 00 00 00	74609 37500	FF 00 00 00	.99609 37500

APPENDIX G (continued)

Hexadec l	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal
.00 00 00 00	.00000 00000	.00 40 00 00	.00097 65625	00 80 00 00	00195 31250	00 C0 00 00	00292 96875
.00 01 00 00	.00001 52587	.00 41 00 00	.00099 18212	.00 81 00 00	.00196 83837	00 C1 00 00	00294 49462
00 02 00 00	00003 05175	.00 42 00 00	00100 70800	.00 82 00 00	.00198 36425	00 C2 00 00	00296 02050
.00 03 00 00	.00004 57763	.00 43 00 00	00102 23388	00 83 00 00	00199 89013	00 C3 00 00	.00297 54638
00 04 00 00	00006 10351	.00 44 00 00	00103 75976	00 84 00 00	.00201 41601	.00 C4 00 00	00299 07226
.00 05 00 00	00007 62939	00 45 00 00	00105 28564	.00 85 00 00	00202 94189	.00 C5 00 00	00300 59814
.00 06 00 00	.00009 15527	.00 46 00 00	00106 81152	.00 86 00 00	00204 46777	.00 C6 00 00	0030 12402
.00 07 00 00	00010 68115	.00 47 00 00	.00108 33740	.00 87 00 00	00205 99365	.00 C7 00 00	00303 64990
00 08 00 00	.00012 20703	00 48 00 00	00109 86328	00 88 00 00	.00207 51953	.00 C8 00 00	00305 17578
00 09 00 00	00013 73291	00 49 00 00	00111 38916	00 89 00 00	00209 04541	.00 C9 00 00	00306 70166
.00 0A 00 00	00015 25878	.00 4A 00 00	00112 91503	00 8A 00 00	.00210 57128	.00 CA 00 00	.00308 22753
00 0B 00 00	.00016 78466	.00 4B 00 00	.00114 44091	.00 8B 00 00	00212 09716	.00 CB 00 00	00309 75341
00 0C 00 00	.00018 31054	00 4C 00 00	00115 96679	00 8C 00 00	00213 62304	00 CC 00 00	00311 27929
00 0D 00 00	.00019 83642	00 4D 00 00	.00117 49267	00 8D 00 00	00215 14892	00 CD 00 00	00312 80517
00 0E 00 00	00021 36230	.00 4E 00 00	00119 01855	00 8E 00 00	.00216 67480	.00 CE 00 00	00314 33105
.00 0F 00 00	.00022 88818	00 4F 00 00	00120 54443	00 8F 00 00	00218 20068	00 CF 00 00	00315 85693
00 10 00 00	.00024 41406	00 50 00 00	00122 07031	.00 90 00 00	00219 72656	.00 D0 00 00	.00317 38281
.00 11 00 00	.00025 93994	00 51 00 00	00123 59619	00 91 00 00	.00221 25244	.00 D1 00 00	.00318 90869
.00 12 00 00	00027 46582	00 52 00 00	00125 12207	00 92 00 00	00222 77832	00 D2 00 00	00320 43457
00 13 00 00	00028 99169	.00 53 00 00	00126 64794	00 93 00 00	00224 30419	.00 D3 00 00	00321 96044
.00 14 00 00	.00030 51757	.00 54 00 00	00128 17382	.00 94 00 00	.00225 83007	.00 D4 00 00	00323 48632
00 15 00 00	.00032 04345	00 55 00 00	00129 69970	.00 95 00 00	.00227 35595	00 D5 00 00	00325 01220
00 16 00 00	00033 56933	.00 56 00 00	00131 22558	00 96 00 00	00228 88183	.00 D6 00 00	.00326 53808
.00 17 00 00	.00035 09521	.00 57 00 00	00132 75146	.00 97 00 00	.00230 40771	.00 D7 00 00	00328 06396
.00 18 00 00	00036 62109	.00 58 00 00	00134 27734	00 98 00 00	00231 93359	00 D8 00 00	.00329 58984
.00 19 00 00	00038 14697	00 59 00 00	00135 80322	.00 99 00 00	.00233 45947	.00 D9 00 00	00331 11572
.00 1A 00 00	00039 67285	00 5A 00 00	00137 32910	00 9A 00 00	00234 98535	00 DA 00 00	00332 64160
00 1B 00 00	00041 19873	00 5B 00 00	00138 85498	00 9B 00 00	00236 51123	.00 DB 00 00	00334 16748
00 1C 00 00	.00042 72460	00 5C 00 00	00140 38085	00 9C 00 00	00238 03710	.00 DC 00 00	00335 69335
00 1D 00 00	00044 25048	00 5D 00 00	00141 90673	00 9D 00 00	00239 56298	.00 DD 00 00	00337 21923
00 1E 00 00	00045 77636	00 5E 00 00	00143 43261	.00 9E 00 00	.00241 08886	00 DE 00 00	00338 74511
00 1F 00 00	00047 30224	00 5F 00 00	00144 95849	00 9F 00 00	00242 61474	.00 DF 00 00	00340 27099
00 20 00 00	.00048 82812	00 60 00 00	00146 48437	00 A0 00 00	00244 14062	00 E0 00 00	.00341 79687
00 21 00 00	00050 35400	00 61 00 00	00148 01025	.00 A1 00 00	00245 66650	00 E1 00 00	00343 32275
00 22 00 00	00051 87988	00 62 00 00	00149 53613	00 A2 00 00	.00247 19238	.00 E2 00 00	.00344 84863
00 23 00 00	00053 40576	.00 63 00 00	00151 06201	00 A3 00 00	00248 71826	00 E3 00 00	00346 37451
00 24 00 00	00054 93164	00 64 00 00	.00152 58789	00 A4 00 00	.00250 24414	00 E4 00 00	00347 90039
00 25 00 00	00056 45751	00 65 00 00	00154 11376	.00 A5 00 00	.00251 77001	00 E5 00 00	00349 42626
00 26 00 00	00057 98339	00 66 00 00	00155 63964	00 A6 00 00	.00253 29589	00 E6 00 00	00350 95214
00 27 00 00	00059 50927	00 67 00 00	00157 16552	00 A7 00 00	00254 82177	00 E7 00 00	00352 47802
00 28 00 00	00061 03515	.00 68 00 00	00158 69140	.00 A8 00 00	00256 34765	00 E8 00 00	00354 00390
00 29 00 00	.00062 56103	00 69 00 00	00160 21728	.00 A9 00 00	00257 87353	00 E9 00 00	.00355 52978
00 2A 00 00	00064 08691	00 6A 00 00	00161 74316	.00 AA 00 00	00259 39941	00 EA 00 00	00357 05566
00 2B 00 00	.00065 61279	00 6B 00 00	.00163 26904	00 AB 00 00	.00260 92529	.00 EB 00 00	00358 58154
00 2C 00 00	00067 13867	00 6C 00 00	00164 79492	00 AC 00 00	00262 45117	00 EC 00 00	00360 10742
00 2D 00 00	00068 66455	00 6D 00 00	00166 32080	00 AD 00 00	.00263 97705	00 ED 00 00	00361 63330
00 2E 00 00	00070 19042	00 6E 00 00	00167 84667	00 AE 00 00	.00265 50292	00 EE 00 00	00363 15917
00 2F 00 00	00071 71630	00 6F 00 00	00169 37255	.00 AF 00 00	00267 02880	.00 EF 00 00	.00364 68505
00 30 00 00	00073 24218	.00 70 00 00	.00170 89843	.00 B0 00 00	00268 55468	.00 F0 00 00	00366 21093
00 31 00 00	.00074 76806	.00 71 00 00	00172 42431	.00 B1 00 00	.00270 08056	00 F1 00 00	00367 73681
00 32 00 00	00076 29394	00 72 00 00	00173 95019	.00 B2 00 00	.00271 60644	.00 F2 00 00	.00369 26269
.00 33 00 00	00077 81982	.00 73 00 00	00175 47607	00 B3 00 00	.00273 13232	00 F3 00 00	00370 78857
00 34 00 00	00079 34570	00 74 00 00	00177 00195	00 B4 00 00	00274 65820	.00 F4 00 00	00372 31445
00 35 00 00	00080 87158	00 75 00 00	.00178 52783	.00 B5 00 00	.00276 18408	00 F5 00 00	.00373 84033
00 36 00 00	.00082 39746	00 76 00 00	.00180 05371	00 B6 00 00	.00277 70996	00 F6 00 00	00375 36621
.00 37 00 00	00083 92333	.00 77 00 00	.00181 57958	00 B7 00 00	.00279 23583	.00 F7 00 00	00376 89208
00 38 00 00	00085 44921	00 78 00 00	00183 10546	00 B8 00 00	00280 76171	00 F8 00 00	00378 41796
00 39 00 00	00086 97509	00 79 00 00	00184 63134	.00 B9 00 00	00282 28759	.00 F9 00 00	00379 94384
00 3A 00 00	00088 50097	00 7A 00 00	00186 15722	.00 BA 00 00	.00283 81347	00 FA 00 00	.00381 46972
.00 3B 00 00	00090 02685	00 7B 00 00	.00187 68310	00 BB 00 00	00285 33935	00 FB 00 00	00382 99560
.00 3C 00 00	.00091 55273	00 7C 00 00	00189 20898	00 BC 00 00	.00286 86523	00 FC 00 00	00384 52148
00 3D 00 00	00093 07861	.00 7D 00 00	00190 73486	.00 BD 00 00	.00288 39111	00 FD 00 00	00386 04736
00 3E 00 00	.00094 60449	00 7E 00 00	00192 26074	00 BE 00 00	00289 91699	00 FE 00 00	00387 57324
00 3F 00 00	.00096 13037	00 7F 00 00	00193 78662	00 BF 00 00	.00291 44287	00 FF 00 00	00389 09912

APPENDIX G (continued)

Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal
00 00 00 00	00000 00000	00 00 40 00	00000 38146	00 00 80 00	00000 76293	00 00 C0 00	00001 14440
00 00 01 00	00000 00596	00 00 41 00	00000 38743	00 00 81 00	00000 76889	00 00 C1 00	00001 15036
00 00 02 00	00000 01192	00 00 42 00	00000 39339	00 00 82 00	00000 77486	00 00 C2 00	00001 15633
00 00 03 00	00000 01788	00 00 43 00	00000 39935	00 00 83 00	00000 78082	00 00 C3 00	00001 16229
00 00 04 00	00000 02384	00 00 44 00	00000 40531	00 00 84 00	00000 78678	00 00 C4 00	00001 16825
00 00 05 00	00000 02980	00 00 45 00	00000 41127	00 00 85 00	00000 79274	00 00 C5 00	00001 17421
00 00 06 00	00000 03576	00 00 46 00	00000 41723	00 00 86 00	00000 79870	00 00 C6 00	00001 18017
00 00 07 00	00000 04172	00 00 47 00	00000 42319	00 00 87 00	00000 80466	00 00 C7 00	00001 18613
00 00 08 00	00000 04768	00 00 48 00	00000 42915	00 00 88 00	00000 81062	00 00 C8 00	00001 19209
00 00 09 00	00000 05364	00 00 49 00	00000 43511	00 00 89 00	00000 81658	00 00 C9 00	00001 19805
00 00 0A 00	00000 05960	00 00 4A 00	00000 44107	00 00 8A 00	00000 82254	00 00 CA 00	00001 20401
00 00 0B 00	00000 06556	00 00 4B 00	00000 44703	00 00 8B 00	00000 82850	00 00 CB 00	00001 20997
00 00 0C 00	00000 07152	00 00 4C 00	00000 45299	00 00 8C 00	00000 83446	00 00 CC 00	00001 21593
00 00 0D 00	00000 07748	00 00 4D 00	00000 45895	00 00 8D 00	00000 84042	00 00 CD 00	00001 22189
00 00 0E 00	00000 08344	00 00 4E 00	00000 46491	00 00 8E 00	00000 84638	00 00 CE 00	00001 22785
00 00 0F 00	00000 08940	00 00 4F 00	00000 47087	00 00 8F 00	00000 85234	00 00 CF 00	00001 23381
00 00 10 00	00000 09536	00 00 50 00	00000 47683	00 00 90 00	00000 85830	00 00 D0 00	00001 23977
00 00 11 00	00000 10132	00 00 51 00	00000 48279	00 00 91 00	00000 86426	00 00 D1 00	00001 24573
00 00 12 00	00000 10728	00 00 52 00	00000 48875	00 00 92 00	00000 87022	00 00 D2 00	00001 25169
00 00 13 00	00000 11324	00 00 53 00	00000 49471	00 00 93 00	00000 87618	00 00 D3 00	00001 25765
00 00 14 00	00000 11920	00 00 54 00	00000 50067	00 00 94 00	00000 88214	00 00 D4 00	00001 26361
00 00 15 00	00000 12516	00 00 55 00	00000 50663	00 00 95 00	00000 88810	00 00 D5 00	00001 26957
00 00 16 00	00000 13113	00 00 56 00	00000 51259	00 00 96 00	00000 89406	00 00 D6 00	00001 27553
00 00 17 00	00000 13709	00 00 57 00	00000 51856	00 00 97 00	00000 90003	00 00 D7 00	00001 28149
00 00 18 00	00000 14305	00 00 58 00	00000 52452	00 00 98 00	00000 90599	00 00 D8 00	00001 28746
00 00 19 00	00000 14901	00 00 59 00	00000 53048	00 00 99 00	00000 91195	00 00 D9 00	00001 29342
00 00 1A 00	00000 15497	00 00 5A 00	00000 53644	00 00 9A 00	00000 91791	00 00 DA 00	00001 29938
00 00 1B 00	00000 16093	00 00 5B 00	00000 54240	00 00 9B 00	00000 92387	00 00 DB 00	00001 30534
00 00 1C 00	00000 16689	00 00 5C 00	00000 54836	00 00 9C 00	00000 92983	00 00 DC 00	00001 31130
00 00 1D 00	00000 17285	00 00 5D 00	00000 55432	00 00 9D 00	00000 93579	00 00 DD 00	00001 31726
00 00 1E 00	00000 17881	00 00 5E 00	00000 56028	00 00 9E 00	00000 94175	00 00 DE 00	00001 32322
00 00 1F 00	00000 18477	00 00 5F 00	00000 56624	00 00 9F 00	00000 94771	00 00 DF 00	00001 32918
00 00 20 00	00000 19073	00 00 60 00	00000 57220	00 00 A0 00	00000 95367	00 00 E0 00	00001 33514
00 00 21 00	00000 19669	00 00 61 00	00000 57816	00 00 A1 00	00000 95963	00 00 E1 00	00001 34110
00 00 22 00	00000 20265	00 00 62 00	00000 58412	00 00 A2 00	00000 96559	00 00 E2 00	00001 34706
00 00 23 00	00000 20861	00 00 63 00	00000 59008	00 00 A3 00	00000 97155	00 00 E3 00	00001 35302
00 00 24 00	00000 21457	00 00 64 00	00000 59604	00 00 A4 00	00000 97751	00 00 E4 00	00001 35898
00 00 25 00	00000 22053	00 00 65 00	00000 60200	00 00 A5 00	00000 98347	00 00 E5 00	00001 36494
00 00 26 00	00000 22649	00 00 66 00	00000 60796	00 00 A6 00	00000 98943	00 00 E6 00	00001 37090
00 00 27 00	00000 23245	00 00 67 00	00000 61392	00 00 A7 00	00000 99539	00 00 E7 00	00001 37686
00 00 28 00	00000 23841	00 00 68 00	00000 61988	00 00 A8 00	00001 00135	00 00 E8 00	00001 38282
00 00 29 00	00000 24437	00 00 69 00	00000 62584	00 00 A9 00	00001 00731	00 00 E9 00	00001 38878
00 00 2A 00	00000 25033	00 00 6A 00	00000 63180	00 00 AA 00	00001 01327	00 00 EA 00	00001 39474
00 00 2B 00	00000 25629	00 00 6B 00	00000 63776	00 00 AB 00	00001 01923	00 00 EB 00	00001 40070
00 00 2C 00	00000 26226	00 00 6C 00	00000 64373	00 00 AC 00	00001 02519	00 00 EC 00	00001 40666
00 00 2D 00	00000 26822	00 00 6D 00	00000 64969	00 00 AD 00	00001 03116	00 00 ED 00	00001 41263
00 00 2E 00	00000 27418	00 00 6E 00	00000 65565	00 00 AE 00	00001 03712	00 00 EE 00	00001 41859
00 00 2F 00	00000 28014	00 00 6F 00	00000 66161	00 00 AF 00	00001 04308	00 00 EF 00	00001 42455
00 00 30 00	00000 28610	00 00 70 00	00000 66757	00 00 B0 00	00001 04904	00 00 F0 00	00001 43051
00 00 31 00	00000 29206	00 00 71 00	00000 67353	00 00 B1 00	00001 05500	00 00 F1 00	00001 43647
00 00 32 00	00000 29802	00 00 72 00	00000 67949	00 00 B2 00	00001 06096	00 00 F2 00	00001 44243
00 00 33 00	00000 30398	00 00 73 00	00000 68545	00 00 B3 00	00001 06692	00 00 F3 00	00001 44839
00 00 34 00	00000 30994	00 00 74 00	00000 69141	00 00 B4 00	00001 07288	00 00 F4 00	00001 45435
00 00 35 00	00000 31590	00 00 75 00	00000 69737	00 00 B5 00	00001 07884	00 00 F5 00	00001 46031
00 00 36 00	00000 32186	00 00 76 00	00000 70333	00 00 B6 00	00001 08480	00 00 F6 00	00001 46627
00 00 37 00	00000 32782	00 00 77 00	00000 70929	00 00 B7 00	00001 09076	00 00 F7 00	00001 47223
00 00 38 00	00000 33378	00 00 78 00	00000 71525	00 00 B8 00	00001 09672	00 00 F8 00	00001 47819
00 00 39 00	00000 33974	00 00 79 00	00000 72121	00 00 B9 00	00001 10268	00 00 F9 00	00001 48415
00 00 3A 00	00000 34570	00 00 7A 00	00000 72717	00 00 BA 00	00001 10864	00 00 FA 00	00001 49011
00 00 3B 00	00000 35166	00 00 7B 00	00000 73313	00 00 BB 00	00001 11460	00 00 FB 00	00001 49607
00 00 3C 00	00000 35762	00 00 7C 00	00000 73909	00 00 BC 00	00001 12056	00 00 FC 00	00001 50203
00 00 3D 00	00000 36358	00 00 7D 00	00000 74505	00 00 BD 00	00001 12652	00 00 FD 00	00001 50799
00 00 3E 00	00000 36954	00 00 7E 00	00000 75101	00 00 BE 00	00001 13248	00 00 FE 00	00001 51395
00 00 3F 00	00000 37550	00 00 7F 00	00000 75697	00 00 BF 00	00001 13844	00 00 FF 00	00001 51991

APPENDIX G (continued)

Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal
00 00 00 00	00000 00000	00 00 00 40	00000 00149	00 00 00 80	00000 00298	00 00 00 C0	00000 00447
00 00 00 01	00000 00002	00 00 00 41	00000 00151	00 00 00 81	00000 00300	00 00 00 C1	00000 00449
00 00 00 02	00000 00004	00 00 00 42	00000 00153	00 00 00 82	00000 00302	00 00 00 C2	00000 00451
00 00 00 03	00000 00006	00 00 00 43	00000 00155	00 00 00 83	00000 00305	00 00 00 C3	00000 00454
00 00 00 04	00000 00009	00 00 00 44	00000 00158	00 00 00 84	00000 00307	00 00 00 C4	00000 00456
00 00 00 05	00000 00011	00 00 00 45	00000 00160	00 00 00 85	00000 00309	00 00 00 C5	00000 00458
00 00 00 06	00000 00013	00 00 00 46	00000 00162	00 00 00 86	00000 00311	00 00 00 C6	00000 00461
00 00 00 07	00000 00016	00 00 00 47	00000 00165	00 00 00 87	00000 00314	00 00 00 C7	00000 00463
00 00 00 08	00000 00018	00 00 00 48	00000 00167	00 00 00 88	00000 00316	00 00 00 C8	00000 00465
00 00 00 09	00000 00020	00 00 00 49	00000 00169	00 00 00 89	00000 00318	00 00 00 C9	00000 00467
00 00 00 0A	00000 00022	00 00 00 4A	00000 00172	00 00 00 8A	00000 00321	00 00 00 CA	00000 00470
00 00 00 0B	00000 00025	00 00 00 4B	00000 00174	00 00 00 8B	00000 00323	00 00 00 CB	00000 00472
00 00 00 0C	00000 00027	00 00 00 4C	00000 00176	00 00 00 8C	00000 00325	00 00 00 CC	00000 00474
00 00 00 0D	00000 00030	00 00 00 4D	00000 00179	00 00 00 8D	00000 00328	00 00 00 CD	00000 00477
00 00 00 0E	00000 00032	00 00 00 4E	00000 00181	00 00 00 8E	00000 00330	00 00 00 CE	00000 00479
00 00 00 0F	00000 00034	00 00 00 4F	00000 00183	00 00 00 8F	00000 00332	00 00 00 CF	00000 00481
00 00 00 10	00000 00037	00 00 00 50	00000 00186	00 00 00 90	00000 00335	00 00 00 D0	00000 00484
00 00 00 11	00000 00039	00 00 00 51	00000 00188	00 00 00 91	00000 00337	00 00 00 D1	00000 00486
00 00 00 12	00000 00041	00 00 00 52	00000 00190	00 00 00 92	00000 00339	00 00 00 D2	00000 00488
00 00 00 13	00000 00044	00 00 00 53	00000 00193	00 00 00 93	00000 00342	00 00 00 D3	00000 00491
00 00 00 14	00000 00046	00 00 00 54	00000 00195	00 00 00 94	00000 00344	00 00 00 D4	00000 00493
00 00 00 15	00000 00048	00 00 00 55	00000 00197	00 00 00 95	00000 00346	00 00 00 D5	00000 00495
00 00 00 16	00000 00051	00 00 00 56	00000 00200	00 00 00 96	00000 00349	00 00 00 D6	00000 00498
00 00 00 17	00000 00053	00 00 00 57	00000 00202	00 00 00 97	00000 00351	00 00 00 D7	00000 00500
00 00 00 18	00000 00055	00 00 00 58	00000 00204	00 00 00 98	00000 00353	00 00 00 D8	00000 00502
00 00 00 19	00000 00058	00 00 00 59	00000 00207	00 00 00 99	00000 00356	00 00 00 D9	00000 00505
00 00 00 1A	00000 00060	00 00 00 5A	00000 00209	00 00 00 9A	00000 00358	00 00 00 DA	00000 00507
00 00 00 1B	00000 00062	00 00 00 5B	00000 00211	00 00 00 9B	00000 00360	00 00 00 DB	00000 00509
00 00 00 1C	00000 00065	00 00 00 5C	00000 00214	00 00 00 9C	00000 00363	00 00 00 DC	00000 00512
00 00 00 1D	00000 00067	00 00 00 5D	00000 00216	00 00 00 9D	00000 00365	00 00 00 DD	00000 00514
00 00 00 1E	00000 00069	00 00 00 5E	00000 00218	00 00 00 9E	00000 00367	00 00 00 DE	00000 00516
00 00 00 1F	00000 00072	00 00 00 5F	00000 00221	00 00 00 9F	00000 00370	00 00 00 DF	00000 00519
00 00 00 20	00000 00074	00 00 00 60	00000 00223	00 00 00 A0	00000 00372	00 00 00 E0	00000 00521
00 00 00 21	00000 00076	00 00 00 61	00000 00225	00 00 00 A1	00000 00374	00 00 00 E1	00000 00523
00 00 00 22	00000 00079	00 00 00 62	00000 00228	00 00 00 A2	00000 00377	00 00 00 E2	00000 00526
00 00 00 23	00000 00081	00 00 00 63	00000 00230	00 00 00 A3	00000 00379	00 00 00 E3	00000 00528
00 00 00 24	00000 00083	00 00 00 64	00000 00232	00 00 00 A4	00000 00381	00 00 00 E4	00000 00530
00 00 00 25	00000 00086	00 00 00 65	00000 00235	00 00 00 A5	00000 00384	00 00 00 E5	00000 00532
00 00 00 26	00000 00088	00 00 00 66	00000 00237	00 00 00 A6	00000 00386	00 00 00 E6	00000 00535
00 00 00 27	00000 00090	00 00 00 67	00000 00239	00 00 00 A7	00000 00388	00 00 00 E7	00000 00537
00 00 00 28	00000 00093	00 00 00 68	00000 00242	00 00 00 A8	00000 00391	00 00 00 E8	00000 00540
00 00 00 29	00000 00095	00 00 00 69	00000 00244	00 00 00 A9	00000 00393	00 00 00 E9	00000 00542
00 00 00 2A	00000 00097	00 00 00 6A	00000 00246	00 00 00 AA	00000 00395	00 00 00 EA	00000 00544
00 00 00 2B	00000 00100	00 00 00 6B	00000 00249	00 00 00 AB	00000 00398	00 00 00 EB	00000 00547
00 00 00 2C	00000 00102	00 00 00 6C	00000 00251	00 00 00 AC	00000 00400	00 00 00 EC	00000 00549
00 00 00 2D	00000 00104	00 00 00 6D	00000 00253	00 00 00 AD	00000 00402	00 00 00 ED	00000 00551
00 00 00 2E	00000 00107	00 00 00 6E	00000 00256	00 00 00 AE	00000 00405	00 00 00 EE	00000 00554
00 00 00 2F	00000 00109	00 00 00 6F	00000 00258	00 00 00 AF	00000 00407	00 00 00 EF	00000 00556
00 00 00 30	00000 00111	00 00 00 70	00000 00260	00 00 00 B0	00000 00409	00 00 00 F0	00000 00558
00 00 00 31	00000 00114	00 00 00 71	00000 00263	00 00 00 B1	00000 00412	00 00 00 F1	00000 00561
00 00 00 32	00000 00116	00 00 00 72	00000 00265	00 00 00 B2	00000 00414	00 00 00 F2	00000 00563
00 00 00 33	00000 00118	00 00 00 73	00000 00267	00 00 00 B3	00000 00416	00 00 00 F3	00000 00565
00 00 00 34	00000 00121	00 00 00 74	00000 00270	00 00 00 B4	00000 00419	00 00 00 F4	00000 00568
00 00 00 35	00000 00123	00 00 00 75	00000 00272	00 00 00 B5	00000 00421	00 00 00 F5	00000 00570
00 00 00 36	00000 00125	00 00 00 76	00000 00274	00 00 00 B6	00000 00423	00 00 00 F6	00000 00572
00 00 00 37	00000 00128	00 00 00 77	00000 00277	00 00 00 B7	00000 00426	00 00 00 F7	00000 00575
00 00 00 38	00000 00130	00 00 00 78	00000 00279	00 00 00 B8	00000 00428	00 00 00 F8	00000 00577
00 00 00 39	00000 00132	00 00 00 79	00000 00281	00 00 00 B9	00000 00430	00 00 00 F9	00000 00579
00 00 00 3A	00000 00135	00 00 00 7A	00000 00284	00 00 00 BA	00000 00433	00 00 00 FA	00000 00582
00 00 00 3B	00000 00137	00 00 00 7B	00000 00286	00 00 00 BB	00000 00435	00 00 00 FB	00000 00584
00 00 00 3C	00000 00139	00 00 00 7C	00000 00288	00 00 00 BC	00000 00437	00 00 00 FC	00000 00586
00 00 00 3D	00000 00142	00 00 00 7D	00000 00291	00 00 00 BD	00000 00440	00 00 00 FD	00000 00589
00 00 00 3E	00000 00144	00 00 00 7E	00000 00293	00 00 00 BE	00000 00442	00 00 00 FE	00000 00591
00 00 00 3F	00000 00146	00 00 00 7F	00000 00295	00 00 00 BF	00000 00444	00 00 00 FF	00000 00593

APPENDIX H

SIAT DATA FILE RECORDS

Table H-1

SIAT Logical Tape Header

Byte	Length	Content	Format
1	12	SIAT Number	EBCDIC (MMS'SI' YYJJJXX)
13	2	Logical Sequence No.	EBCDIC (XX)
15	10	Date of Tape Preparation	EBCDIC (bDDbMMbYY)
25	10	ZERO	BINARY
35	14	SIAT Number and Sequence No.	EBCDIC (MMS'SI'YYJJJXXXX)
49	8	RBV Tape Number	EBCDIC (TTADDDNN or blanks)
57	8	MSS Tape Number	EBCDIC (TTADDDNN or blanks)
65	2	Number of Data Files on Logical SIAT	INTEGER
67	2	ZERO	BINARY
69	2	ZERO	BINARY
71	2	Number of RBV/VTC	INTEGER
73	2	Number of MSS/VTC	INTEGER
75	2	Number of RBV/TFC	INTEGER
77	2	Number of MSS/TFC	INTEGER
79	768	1st-64th RBV Scene ID's	EBCDIC ADDDD-HHMMSb
847	768	1st-64th MSS Scene ID's	EBCDIC ADDDD-HHMMSb
1615	2	Header Flag	XXAA
1617	432	ZERO	BINARY
2048 Total Bytes			

Inter-Record Gap

Table H-2
Calibration Modifiers
(M's and A's)

Starting Byte No. and Length (Bytes)		Information	Format
1	2	Satellite ID	Binary
3	2	Days since Launch	Binary
		Band 4 Low Gain/ Compressed Mode	
5	2	Sensor 1 - Multiplicative Constant	Binary (16.8)
7	2	Sensor 2 - "	" "
9	2	Sensor 3 - "	" "
11	2	Sensor 4 - "	" "
13	2	Sensor 5 - "	" "
15	2	Sensor 6 - "	" "
17	2	Sensor 1 - Additive Constant	" "
19	2	Sensor 2 - "	" "
21	2	Sensor 3 - "	" "
23	2	Sensor 4 - "	" "
25	2	Sensor 5 - "	" "
27	2	Sensor 6 - "	" "
		Band 4 Low Gain/Linear Mode	
29	24	Same as bytes 5 - 28	
		Band 4 High Gain/ Compressed Mode	
53	24	Same as bytes 5 - 28	Binary (16.8)
		Band 4 High Gain/ Linear Mode	
77	24	Same as bytes 5 - 28	Binary (16.8)
		Band 5	
101	96	Same as bytes 5 - 28	Binary (16.8)
		Band 6 Low Gain/ Linear Mode	
197	24	Same as bytes 5 - 28	Binary (16.8)
		Band 6 Low Gain/ Compressed Mode	
221	24	Same as bytes 5 - 28	Binary (16.8)
		Band 7 Low Gain/ Linear Mode	
245	24	Same as bytes 5 - 28	Binary (16.8)

Table H-3
Processing Instruction Data
Record 3

Starting Byte No. and Length (Bytes)		Information	Format
1	2	No. of Scenes Remaining, RBV/VFC	Binary
3	2	No. of Scenes Remaining, MSS/VFC	Binary
5	2	No. of Scenes Remaining, RBV/VTC	Binary
7	2	No. of Scenes Remaining, MSS/VTC	Binary
9	2	Not Used	Binary Zero
11	2	Not Used	Binary Zero
13	12	Scene ID	EBCDIC ndddd-hhmmsb
25	24	Not Used = 0	
49	1	Mission No. (1, 2 or 3)	Binary
50	1	Day Number From Launch	Binary (most significant part; least significant bit is 2^6)
51	1	Day Number From Launch	Binary (6-bit least signif. part; 6 bits available)
52	1	Hours of Day	Binary
53	1	Minutes of Hour	Binary
54	1	Tens of Seconds	Binary
55	138	Not Used	Binary Zero
193	1	Mission No.	Binary
194	1	Day Number From Launch	Binary (most significant part; least significant bit is 2^6)
195	1	Day Number From Launch	Binary (6-bit least signif. part, 6 bits available)
196	1	Hours of Day	Binary
197	1	Minutes of Hour	Binary
198	1	Tens of Seconds	Binary
199	1	Not Used	Binary Zero
200	1	Not Used	Binary Zero
201	6	Output Frame ID	Same as Item 38
207	1	Not Used	Binary Zero
208	1	Not Used	Binary Zero
209	2	Processing Code from SLAT	Binary
211	2	Processing Code for MSS	Binary
213	2	Polar Stereo Projection	HEXADECIMAL
215	8	FLAG	Binary Zero
222	Total Bytes		

Inter-Record Gap

Table H-4
Spacecraft Performance Data
Record 4

Starting Byte No. and Length (Bytes)		Information	Format
1	8	RBV 1 Mode of Transmission	EBCDIC RBVb1bba
9	2	RBV 1 Exposure Duration	EBCDIC Xa
11	2	RBV 1 Aperture Correction Indicator	EBCDIC ab
13	8	RBV 2 Mode of Transmission	EBCDIC RBVbb2ba
21	2	RBV 2 Exposure Duration	EBCDIC Xa
23	2	RBV 2 Aperture Correction Indicator	EBCDIC ab
25	8	RBV 3 Mode of Transmission	EBCDIC RBVbbb3a
33	2	RBV 3 Exposure Duration	EBCDIC Xa
35	2	RBV 3 Aperture Correction Indicator	EBCDIC ab
37	12	MSS 4 Mode of Transmission	EBCDIC MSSb4bbbbab
49	12	MSS 5 Mode of Transmission	EBCDIC MSSbb5bbbbab
61	12	MSS 6 Mode of Transmission	EBCDIC MSSbbb6bbbab
73	12	MSS 7 Mode of Transmission	EBCDIC MSSbbbb7bbab
85	12	MSS 8 Mode of Transmission	EBCDIC MSSbbbbb8bab
97	2	MSS Sensor Gain	Binary, bits 1 & 2 for bands 4 & 5 respectively; 1=high, Bits 3-16 are zero
99	1	MSS Sensor Encoding	Binary, bits 1-3, for bands 4-6 respectively; 1=compressed; Bits 4-8 are zero
100	1	Not Used	Binary Zero
101	8	SPDT Tape ID	EBCDIC SPnddddnn
109	4	MSS SUN CAL DAY	EBCDIC OODDD
113	48	MSS SUN CAL's SENSORS 1-24	Binary Scaled 2^{-12}
160	Total Bytes		

Inter-Record Gap

Table H-5
Annotation Block Data
Record 5

Starting Byte No. and Length (Bytes)		Information	Format
1	2	Day of Month Exposure	EBCDIC nn
3	3	Month of Exposure	" aaa
6	2	Year of Exposure	" nn
8	3	Constant	" bCb
11	6	Latitude of Format Center	" ann-nn
17	1	Constant	'/'
18	7	Longitude Format Center	" annn-nn
25	1	Blank	" b
26	1	*Descending or Ascending	'D' or 'A'
27	7	*Frame Path/Row Number	" xxx-xxx
34	1	Blank	" b
35	1	Constant for Nominal Location	" 'N'
36	1	Blank	" b
37	6	*Nominal Latitude	" ann-nn
43	1	Character	" '/'
44	7	*Nominal Longitude	" annn-nn
51	1	Blank	" b
52	1	Sensor Code	" 'M' or 'R'
53	7	Designated Band	" '4', '5','6' or 7
60	1	Transmission Mode	" 'D' or 'R'
61	9	Sun Elevation (deg.)	" bSUNbELnn
70	6	Sun Azimuth (deg.)	" bAnnnb
76	12	Image Processing Codes	UIL-CD-NbLab
88	13	Constant	" NASAbLANDSATb
101	13	**Scene Identification	" 'E-xxxxx-xxxxx'
114	1	Constant	" '_'
115	1	Blank	" b
116	1	Blank	b
117	24	Reserved for RBV	
141	4	MSS Mode & Acquisition Site	" 'Dba-'
144	Total Bytes		

* Value may be zero for some retrospective imagery acquired prior to February 22, 1977.

** 'E-xbxxx-xxxxx' for some tapes generated between Feb. and May 1978.

Table H-6
RBV Computational Data
Record 6

Starting Byte No. and Length (Bytes)		Information	Format
1	8	Spacecraft time of Exposure	4-bit BCD OOOOOdddhhmmssec
9	8	Greenwich Mean Time of Exposure	4-bit BCD OOOdddhhmmssmmmO
17	2	Normalized Altitude Change	Binary fraction
19	10	GMT Date of Exposure	EBCDIC hddlmmmbyy
29	8	GMT Time of Exposure	EBCDIC bhhmm:ss
37	4	Latitude of Format Center (10^{-6} Radians)	Binary
41	4	Longitude of Format Center (10^{-6} Radians)	Binary
45	4	Latitude of Nadir (10^{-6} Rad.)	Binary
49	4	Longitude of Nadir (10^{-6} Rad.)	Binary
53	4	Spacecraft Altitude (meters)	Binary
57	4	GMT of Exposure (Milliseconds of Day)	Binary
61	4	S/C Flight Path Heading (10^{-6} Radian)	Binary
65	4	Pitch (10^{-6} Radian)	Binary
69	4	Roll (10^{-6} Radian)	Binary
73	4	Yaw (10^{-6} Radian)	Binary
76	Total Bytes		

Inter-Record Gap

NOTE: The negative representation of the binary fraction (15 bits plus signed bit) in the 32 bit binary data words is two's complement. A scale factor of 2^{-17} should be used with the 32 bit binary data words.

Table H-7
MSS Computational Data
Record 7

Starting Byte No. and Length (Bytes)		Information	Format
1	8	Spacecraft Time of Scene Center	4-bit BCD 00000ddhhmmsscc
9	8	GMT of Scene Center	4-bit BCD 000dddhhmmssmmm0
17	2	Normalized Altitude Change at Image Center - 13.80300	Binary fraction
19	2	Same as 102 at I.C. - 10.35225	" "
21	2	Same as 102 at I.C. - 6.90150	" "
23	2	Same as 102 at I.C. - 3.45075	" "
25	2	Same as 102 at I.C. Time	" "
27	2	Same as 102 at I.C. +3.45075	" "
29	2	Same as 102 at I.C. +6.90150	" "
31	2	Same as 102 at I.C. +10.35225	" "
33	2	Same as 102 at I.C. +13.80300	" "
35	2	Altitude (N.M./32) at time of 102	Binary
37	16	8 Values of Alt. at the times of Items 103-110, respect.	Binary, 2 bytes per value
53	2	Vehicle Roll at Image Center Time (Rad.)	Binary fraction
55	2	Vehicle Pitch at I.C. (Rad.)	Binary fraction
57	2	Vehicle Yaw at I.C. (Rad.)	Binary fraction
59	2	Roll at Time of Item 102 (Rad.)	Binary fraction
61	16	8 Values of Roll at the times of Items 103-110, respect.	Binary fraction, 2 bytes per value
77	2	Pitch at time of Item 102 (Rad.)	Binary fraction
79	16	8 Values of Pitch at the times of Items 103-110, respect.	Binary fraction, 2 bytes per value
95	2	Yaw at Time of Item 102 (Rad.)	Binary fraction
97	16	8 Values of Yaw at the Times of Items 102-110, respect.	Binary fraction, 2 bytes per value
113	2	Image Skew (Rad.)	Binary fraction
115	2	Normalized Velocity Change	Binary fraction
117	4	Mean Pitch (10^{-6} Rad.)	Binary
121	4	Mean Roll (10^{-6} Rad.)	Binary
125	4	Mean Yaw (10^{-6} Rad.)	Binary
129	4	Mean Pitch Rate (10^{-6} Rad/Sec.)	Binary
133	4	Mean Roll Rate (10^{-6} Rad/Sec.)	Binary

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Table H-7 (continued)
MSS Computational Data
Record 7

Starting Byte No.	Length (Bytes)	Information	Format
137	4	Mean Yaw Rate (10^{-6} Rad/Sec.)	Binary
141	4	Mean Altitude (meters)	Binary
145	4	Mean Altitude Rate (Meters/Sec.)	Binary
149	4	GMT Milliseconds of Day at ICT - 25 SEC.	Binary
153	4	GMT Milliseconds of Day at ICT - 25 SEC.	
157	4	GMT Milliseconds of Day at ICT - 15 SEC.	Binary
161	4	GMT Milliseconds of Day at ICT - 10 SEC.	Binary
165	4	GMT Milliseconds of Day at ICT - 5 SEC.	Binary
169	4	GMT Milliseconds of Day at ICT	Binary
173	4	GMT Milliseconds of Day at ICT +5 SEC.	Binary
177	4	GMT Milliseconds of Day at ICT + 10 SEC.	Binary
181	4	GMT Milliseconds of Day at ICT +15 SEC.	Binary
185	4	GMT Milliseconds of Day at ICT +20 SEC.	Binary
189	4	GMT Milliseconds of Day at ICT +25 SEC.	Binary
193	44	Eleven Values of Nadir Latitude at Times of Items 160-170 (10^{-6} Rad.)	Binary
237	44	Eleven Values of Nadir Longitude at Times of Items 160-170 (10^{-6} Rad.)	Binary
281	44	Eleven Values of Altitude at Times of Items 160-170 (Meters)	Binary
324		Total Bytes	

Inter-Record Gap

NOTE: The negative representation, of the binary fraction (15 bits plus signed bit) in the 32 bit binary data words is two's complement. A scale factor of 2^{-17} should be used with the 32 bit binary data words.

Table H-8

Image Location Data

Record 8

Starting Byte No. and Length (Bytes)		Information	Format
1	10	RBV, Top Edge, Tick Mark No. 1, Position and Annotation	Binary Fraction and EBCDIC
11	50	5 More Tick Marks as Above for the Same Edge	"
61	60	Same as Items 204 and 205 for the Left Edge	"
121	60	Same as Above for the Right Edge	"
181	60	Same as Above for the Bottom Edge	"
241	240	Same as Items 204 - 208 for the MSS	"
480 Total Bytes			

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APPENDIX I

DETECTOR-TO-DETECTOR RADIOMETRIC ACCURACY

Tests have been made using a computer program (EVAL) to evaluate the video data on the Bulk MSS CCT. The radiance levels have been sorted into three ranges (referred to as regions and corresponding to the intervals 0 to 20, 21 to 60 and 61 to 127). As part of the evaluation, a confidence check is used which requires at least 50 data points within a region for each detector in a mirror sweep. If a detector has fewer than 50 data points for a region, then none of the data in that region are used in evaluating the data for that particular mirror sweep. The computer output includes an area which lists the number of samples for each detector. These samples refer to the number of mirror sweeps for which the data satisfy the confidence check. The results of EVAL have been useful in detecting striping problems and in comparing detector-to-detector radiometric accuracy.

Two CCTs have been chosen to demonstrate the usefulness of the program's output. One CCT has video data which has not been radiometrically corrected using the new regression coefficients (C's and D's) for Landsat-1. The video data on the other CCT have been radiometrically corrected using the new C's and D's. These tapes are referred to as "before" and "after" CCTs respectively.

Figure I-1 shows, in summary form, the average radiance level for each detector. The averaging is calculated for each mirror sweep, which consists of six scan lines. As can be seen in Figure I-2, the difference in radiance levels among the detectors for a given region is not more than two quantum levels. By referring to Figure I-1 and I-2, the detector-to-detector radiometric accuracy of the "before" and "after" CCTs can be compared. It will be noticed that the ranges of values on "before" and "after" CCTs are quite different. This is because slightly different areas are represented on each CCT; however, a comparison of the differences between detectors is meaningful. For example, note that detectors 2 and 4 of band 3, region 3 were quite high and low respectively on the "before" CCT. The corresponding detectors on the "after" CCT show considerable improvement.

BULK MSS CCT
SCENE/FRAME ID 198-07441
CCT SEQ. NO. 4 OF 4
CONFIDENCE LIMIT 50

	AVR RADIANCE LEVEL FOR EACH DETECTOR						NO. OF SAMPLES FOR EACH DETECTOR					
	1	2	3	4	5	6	1	2	3	4	5	6
BAND 1												
RE[illegible] 1	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0
RE[illegible] 2	41.0	42.2	41.4	42.0	40.8	40.4	50	50	50	50	50	50
R[illegible] 3	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0
BAND 2												
RE[illegible] 1	11.0	11.7	12.0	11.5	12.1	11.9	15	15	15	15	15	15
RE[illegible] 2	45.2	44.9	44.9	44.2	44.3	44.7	50	50	50	50	50	50
RE[illegible] 3	69.4	68.8	67.9	67.4	67.8	68.9	47	47	47	47	47	47
BAND 3												
RE[illegible] 1	8.9	9.1	8.9	7.8	7.7	8.2	18	18	18	18	18	18
RE[illegible] 2	43.1	43.1	43.7	42.9	43.6	43.6	50	50	50	50	50	50
RE[illegible] 3	74.2	79.3	75.7	71.3	78.0	74.6	15	15	15	15	15	15
BAND 4												
RE[illegible] 1	12.9	12.9	12.7	12.7	12.7	12.7	50	50	50	50	50	50
RE[illegible] 2	23.2	24.2	23.3	23.3	23.7	23.2	50	50	50	50	50	50
RE[illegible] 3	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0

STOP 0

Figure I-1. Average Radiance Levels for the "before" CCT

BULK MSS CCT
SCENE/FRAME ID 198-07441
CCT SEQ. NO. 4 OF 4
CONFIDENCE LIMIT 50

	AVG RADIANCE LEVEL FOR EACH DETECTOR						NO. OF SAMPLES FOR EACH DETECTOR					
	1	2	3	4	5	6	1	2	3	4	5	6
BAND 1												
REGION 1	17.1	16.9	16.4	16.9	17.1	16.2	17	17	17	17	17	17
REGION 2	34.7	34.0	34.1	34.3	34.1	34.2	50	50	50	50	50	50
REGION 3	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0
BAND 2												
REGION 1	19.4	19.5	19.0	19.1	19.3	19.0	27	27	27	27	27	27
REGION 2	39.3	39.5	39.4	39.7	39.4	39.1	50	50	50	50	50	50
REGION 3	71.6	72.3	71.4	73.4	72.5	72.1	22	22	22	22	22	22
BAND 3												
REGION 1	14.6	14.5	14.2	14.1	13.2	13.9	44	44	44	44	44	44
REGION 2	38.1	.8	38.3	38.1	38.0	37.5	50	50	50	50	50	50
REGION 3	78.4	77.9	77.6	77.1	76.3	76.7	22	22	22	22	22	22
BAND 4												
REGION 1	12.7	12.7	12.4	12.4	12.7	12.4	50	50	50	50	50	50
REGION 2	24.9	25.1	25.1	25.2	25.3	25.1	50	50	50	50	50	50
REGION 3 DETOR 3	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	

Figure I-2. Average Radiance Levels for the "after" CCT