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

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Valerie L. Thomas
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Information Processing Division

November 1975

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

FOREWORD

This document discusses the format and physical characteristics of the LANDSAT multispectral 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 and the radiometric calibration of the video data respectively.

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

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ABSTRACT

This document discusses the generation and format of the Landsat 1 and 2 system corrected multispectral scanner computer compatible tapes. 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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CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (continued)

TABLES

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 AND 2 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

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 is a four-band scanner operating in the solar-reflected spectral region from 0.5 to 1.1 micrometers. It 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 recieving sites. The recieving 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 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 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.

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.

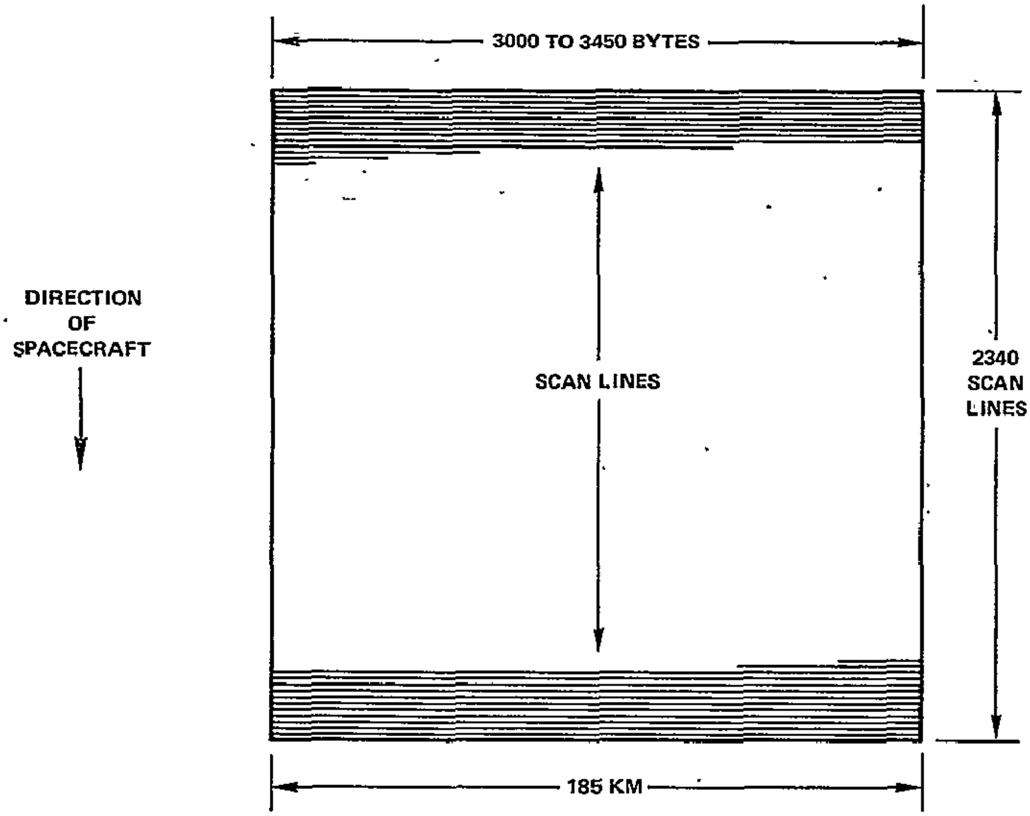

Figure 1. Components of a Completed Ground Scene as Represented on the MSS CCT

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.

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.

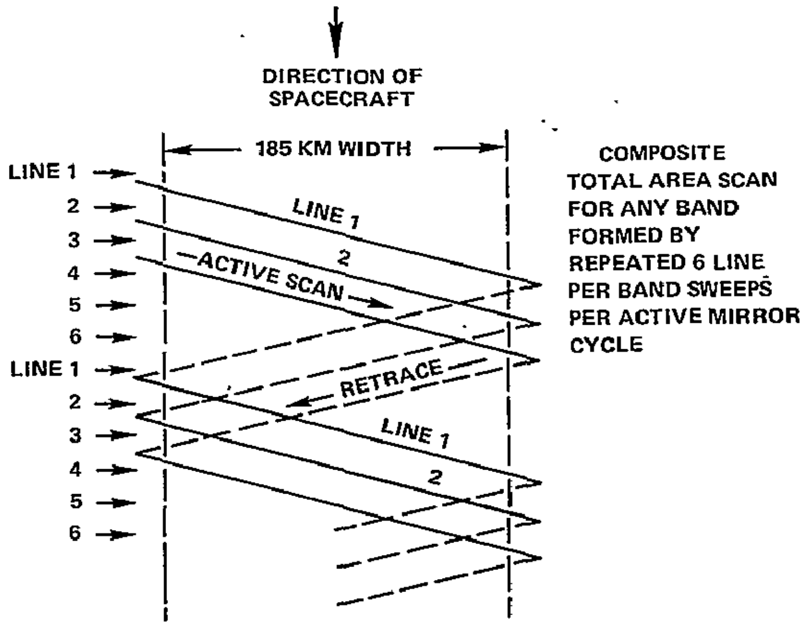

Figure 2. Ground Scan Pattern for a Single MSS Detector

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.

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.

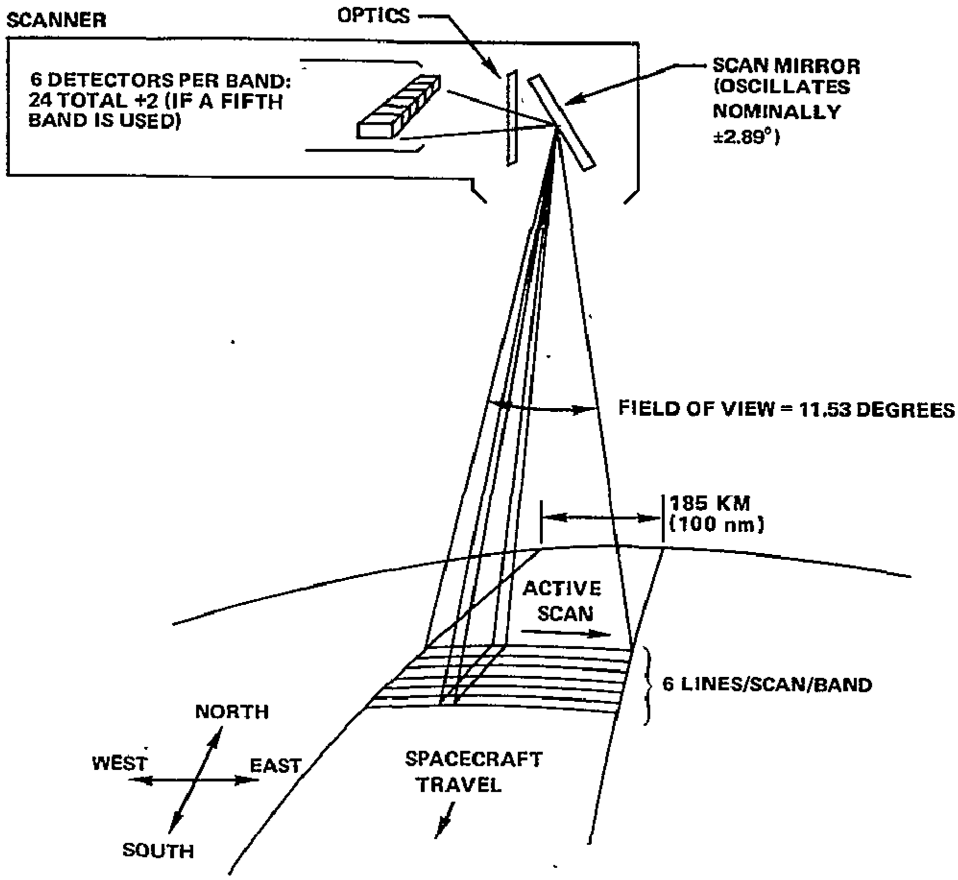

Figure 3. MSS Scanning Arrangement

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 and -2, and includes the fifth band for future Landsat mission. 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 SIAT file. See Figure 19 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

Table 1
ID Record Information Definitions

Char.	Information	Format	Code
1-12	Scene/Frame ID B = spectral band identifier N = sequential subframe ID b = blank char.	EDDD-HHMMSBN*	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)	AAnnnnnn	EBCDIC
37-38	MSS Data Mode/Correction Code*** Unitary Code	nn	Binary
39-40	MSS Adjusted Line Length	nn	Binary

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*E — Encoded Project Identifier
LandSat I - 1 or 5
LandSat II - 2 or 6
DDD — 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 — NDPF Identification Code (RBV: 1, 2, 3; MSS: 4, 5, 6, 7, 8)

**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	Spectral Band Identifier
26	Sequential Subframe ID

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

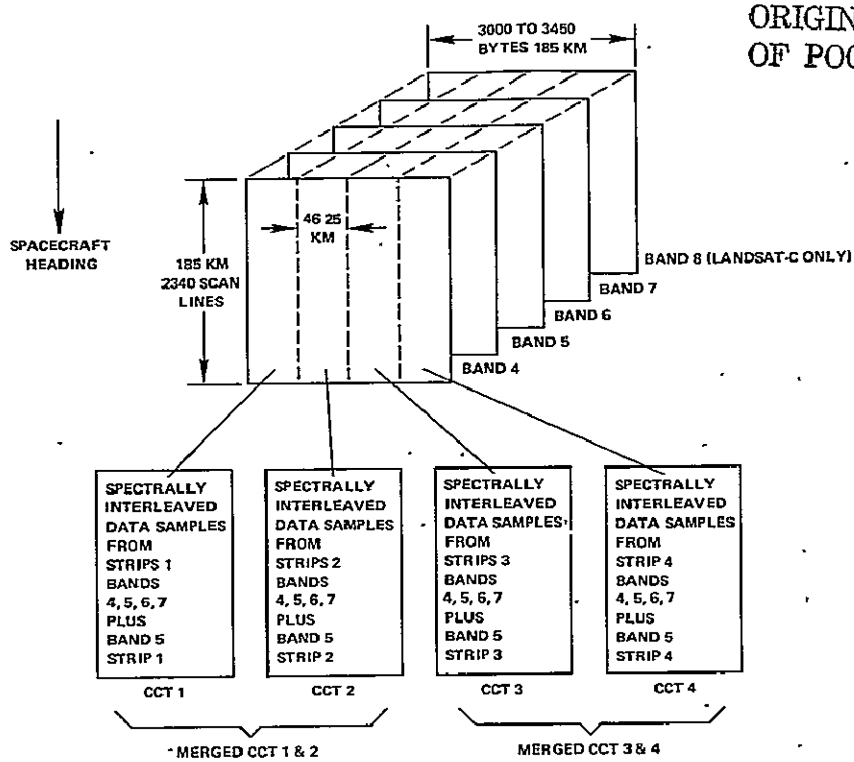

Figure 4. Bulk MSS Image-to-CCT Conversion

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 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 two missions. For Landsat-1 and -2, the four spectral bands 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.

For a future Landsat mission, a fifth band (band 8) will be added that operates in the thermal (emissive) spectral region from 10.4 to 12.6 micrometers. This band uses mercury-cadmium-telluride, long-wave infrared detectors.

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.

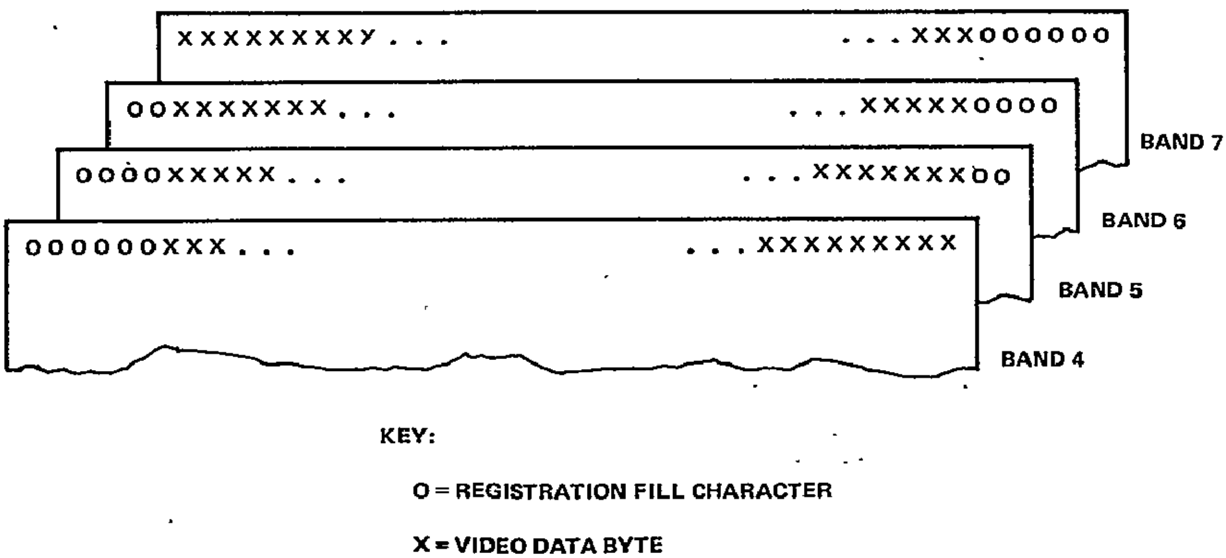

Figure 5. Position of Registration Fill Characters in Spectral Bands

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 lines. The "synthetic" byte is a duplicate of the last byte preceding it on the scan 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.

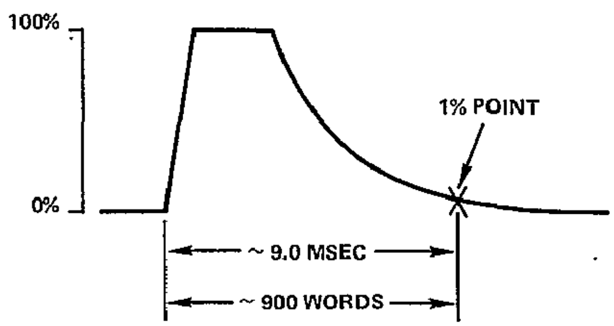

Figure 6. Nominal Calibration Wedge Output

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.

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, spacecraft heading, 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.

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 the spectral band, sequential subframe ID, and whether the data are from Landsat-1 or -2. 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

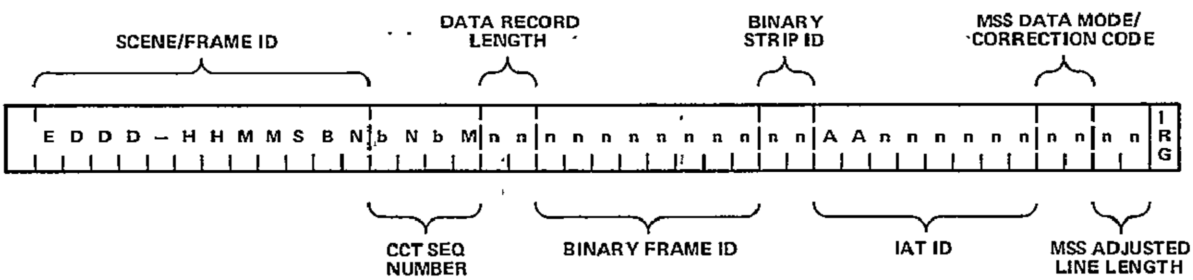

Figure 7. ID Record Organization (40 Characters, EBCDIC and Binary Code)

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

SPECTRAL BAND 0  SUBFRAME 0  SCENE/FRAME ID: 053D 16H 48M 2S
CCT SEQ. NO.  1 OF 4   DATA RECORD LENGTH   3296
BINARY FRAME ID 5 531648200          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

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 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.

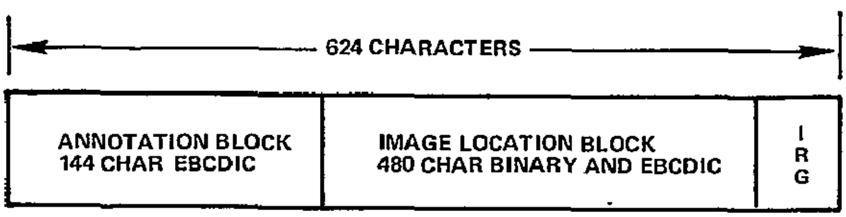

Figure 9. Annotation Record Information Sequence

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 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: 053DY 16HR 48MN 2S

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

SUN ANGLES        S/C      ORBIT  STATN    IMAGE      EPHEM.
EL     AZ       HEADING    REV             SIZE        DATA
58     099      189DEG     4683          100X100NM      D

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

 MSS DATA   ACQUIS.
             SITE
    D         G
```

Figure 10. Sample Output from the Val Dump Program

Table 2
Annotation Block Data

Characters	Description
	Day, Month, Year of Exposure — The date at Greenwich, month, and year of picture exposure.
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).
	Format Center — The center of the RBV and MSS image format is indicated in terms of latitude and longitude in degrees and minutes. The MSS format center shall be identical to the RBV format center. 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.
25–27	Constant: 'bNb' (signifies Nadir).
	Nadir — The latitude and longitude of the nadir (the intersection with the earth's surface of a line from the satellite perpendicular to the earth ellipsoid) shall be indicated in degrees and minutes.
28	Latitude direction, 1 alpha, N or S.
29–30	Latitude, degrees, two numerals.
31	Constant: '–'.
32–33	Latitude, minutes, two numerals.
34	Constant: '/'.

Table 2
Annotation Block Data (continued)

Characters	Description
35	Longitude, direction, 1 alpha, E or W.
36-38	Longitude, degrees, three numerals.
39	Constant: '-'.
40-41	Longitude, minutes, two numerals.
42	Constant: 'b'.
43-54	Blank Field 1 (12 characters long)
55-60	Constant: 'SUNbEL'.
61-62	Sun elevation, degrees, two numerals.
	Sun Elevation — The sun elevation angle at the time of RBV exposure or midpoint of MSS frame shall be specified to the nearest degree.
63-65	Constant: 'bAZ'.
	Sun azimuth, degrees, three numerals.
	Sun Azimuth — The sun azimuth angle from true North at the time of RBV exposure or midpoint of MSS frame shall be specified to the nearest degree.
69	Constant: 'b'.
70-72	Heading of orbital path, including yaw, degrees, three numerals.
	Satellite Heading — The satellite heading shall be specified to indicate the orientation of the imagery. The heading includes yaw and is specified to nearest degree.
73	Constant: '-'.
74-77	Revolution number, four numerals.
	Rev Number — The consecutive rev number for the Landsat spacecraft shall be specified.
78	Constant: '-'.
79	MSS data acquisition site, abbreviated to one alpha, A, G or N.
	Data Acquisition Site — A one-letter acronym designates the data acquisition site. This will be either Alaska, (A), Goldstone, (G), or NASA Tracking and Training Facility (N).
80	Constant: '-'.
81	Constant: '1'.

Table 2
Annotation Block Data (continued)

Characters	Description
82	Constant: '-'.
83-84	Blank Field 2 (two characters long).
85	Type of orbit data, Predicted = P; Definitive = D.
86	Constant: '-'.
87-88	Blank Field 5 (two characters long).
89-101	Constant: bNASAbERTSb-'.
	Frame Identification
	Frame Identification Number — Each image or frame has a unique identifier which contains encoded information. This identifier shall be used for an information retrieval system and will consist primarily of time of exposure relative to launch information. The Initial Image Generating Subsystem will add the appropriate spectral band number. Also part of the frame identification number is a "regeneration of images" identifier. This identifier will also be added by Initial Image Generation Processing to the imagery when appropriate.
102	Landsat mission number = S
103-105	Day number relative to launch = DDD S = 1 for Landsat 1 and DDD ≤ 999 S = 5 for Landsat 1 and DDD > 999 S = 2 for Landsat 2 and DDD ≤ 999 S = 6 for Landsat 2 and DDD > 999
106	Constant: '-'.
107-108	Hour at time of observation.
109-110	Minutes.
111	Tens of seconds.
112	Constant: '-'.
113	Blank Field 3 (one character long).
114	Blank for earth images. RC1 Images — A 0, 1, and 2 to reflect the 3 exposure levels for radiometric calibration, where 0 corresponds to the minimum exposure level, and 2 corresponds to the maximum. A Blank signifies no RCI images.
115-116	Blank Field 4 (two characters long).
	During Initial Image Generation Processing, the sensor code will be inserted on the imagery into Blank Field 1; the gamma

Table 2
Annotation Block Data (continued)

Characters	Description
	(normal 'N-', or abnormal 'A-') into Blank Field 2; the spectral identifier into Blank Field 3; the regeneration number of the processed image (when necessary) into Blank Field 4; and the type of MSS signal encoding into Blank Field 5.
117-140	24 blank characters if RBV is off.
141-144	4 blank characters if MSS is off.
	Otherwise:
117-121	Direct or recorded data: '1bbDX' or 'bbRX'.
122-123	Shutter Setting* and Aperture Correction Indicator,**RBV 1; aa
124-129	Direct or recorded data: 'bb2bDX' or 'bb2bRX'.
130-131	Shutter Setting and Aperture Correction Indicator, RBV 2; aa
132-137	Direct or recorded data: 'bbb3DX' or 'bbb3RX'.
138-139	Shutter Setting and Aperture Correction Indicator, RBV; aa
140	Constant: 'b'.
141-142	Direct or recorded MSS data: 'Db' or 'Rb'.
143-144	MSS data acquisition site, 'A-', 'G-', or 'N-'.

*Shutter setting code, applicable to RBV annotation only:

Setting	Duration of exposure		
	camera 1	camera 2	camera 3
A	4.0	4.8	6.3
B	5.6	6.4	7.2
C	8.0	8.8	8.8
D	12.0	12.0	12.0
E	16.0	16.0	16.0

**Aperture correction indicator:

I = Aperture correction in
O = Aperture correction out

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 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; 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:

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

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

Decompressed

O	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 the 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 represents all the shades of gray).

TICK MARK LOCATIONS

	********* TOP EDGE ********				******* LEFT EDGE *********			
	POSIT.	DIRECT	TICK CHAR	VALUE	POSIT.	DIRECT	TICK CHAR	VALUE
1	7069	W	|	106-30	#####	N	•	033-30
2	64296	W	|	106-00	64238	N	•	033-00
3	-9574	W	|	105-30	8608	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	|	032-00
2477	N	•	032-30	9439	W	|	107-00
12441	N	•	032-00	985	W	|	106-30
0			-	58041	W	|	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 O's represent registration fill characters and the X's represent video data bytes:

First three groups

OO OO OO XX   OO OO XX XX   OO XX XX XX

Last three groups

XX XX XX OO   XX XX OO OO   XX OO OO OO

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-1

The Landsat-1 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.

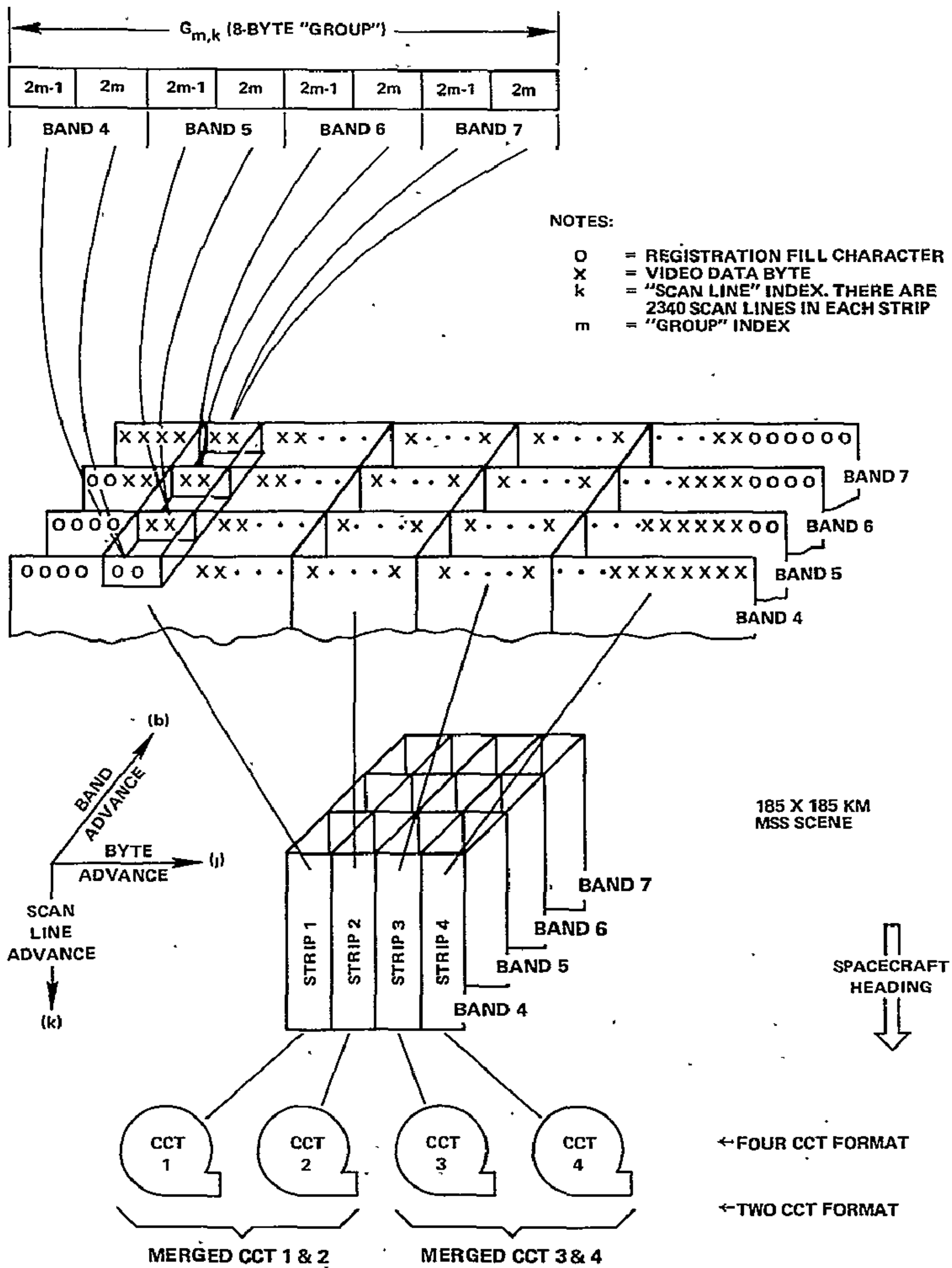

Figure 12. Bulk MSS Four-Band Scene to Interleaved CCT Conversion

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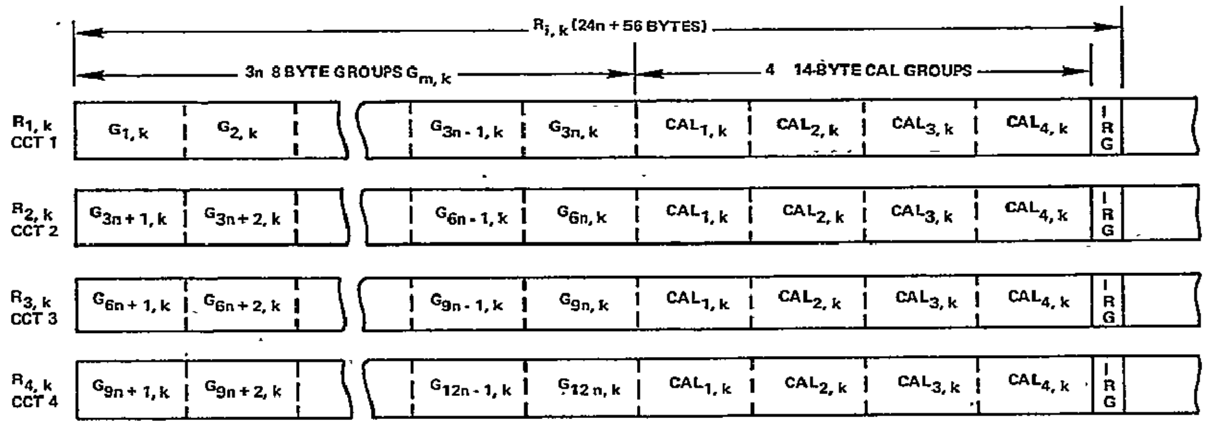
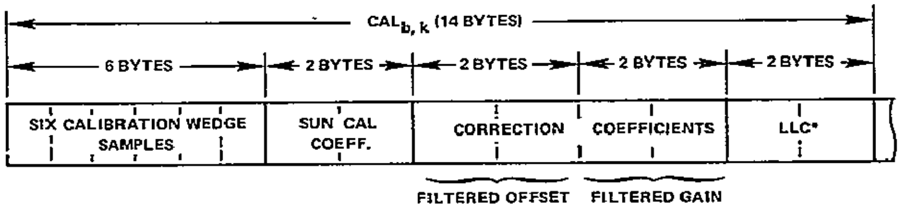


Figure 13. Bulk MSS Full Scene Interleaved Record Format
(Line Length Adjusted to N=24n Samples)



* 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	
$\hat{U}_{sn}$	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	16	13	5	2	1. 0	1.21	45. 0	3219
CAL2,	1	46	42	20	18	12	9	1. 0	0.54	51.68	3219
CAL3,	1	50	45	37	16	14	12	1. 0	0.62	67.22	3219
CAL4,	1	33	25	20	6	5	4	1. 0	0. 0	64. 0	3219

Figure 15. Val Dump Printout of 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.

Video Data Record for a Future Fifth Band

The special fifth band video data record $B_{i,k}$ contains 2n (the same n used in calculating the adjusted line length) video data points and 14 bytes of calibration data for the fifth band. The format for the cal data is the same as that for the other bands. Figure 17 is a diagram of the $B_{i,k}$, where k is the sequential Band 8 scan line index and i is the image segment and computer-compatible tape number.

******* VIDEO DATA FROM THE FIRST MSS INTERLEAVED SCAN LINE *******

BANDS

4	**5**	**6**	**7**	**4**	**5**	**6**	**7**	**4**	**5**	**6**	**7**	**4**	**5**	**6**	**7**
FF FF	FF FF	FF FF	17 17	FF FF	FF FF	34 38	16 15	FF FF	30 31	34 2F	15 13	2B 26	30 2B	2E 2B	12 11
29 2D	30 36	2B 36	14 16	30 2D	39 34	38 34	17 16	30 33	39 3E	34 38	17 18	33 33	3B 36	3B 38	19 16
2D 30	36 39	38 38	17 17	30 30	39 39	38 36	17 17	33 33	3B 3E	3B 3B	18 17	33 33	3E 3B	3B 3B	18 19
33 35	3B 41	3D 3F	19 1A	30 30	39 34	36 32	16 14	3B 33	41 41	43 41	18 19	33 30	39 39	36 3B	18 18
33 33	3E 3B	3F 38	19 18	33 35	3B 41	3B 3F	18 1A	33 33	3E 39	3D 3B	19 18	33 33	39 3E	38 3B	18 19
33 33	3B 3B	3D 3B	19 17	33 33	3B 3E	3D 3F	18 1A	33 33	3B 3B	3B 3D	1A 18	35 30	3E 3B	3D 3B	19 18
30 33	3B 39	3B 3F	19 18	30 30	39 39	3B 3D	17 18	30 30	3B 36	3B 38	18 17	30 33	36 36	36 36	17 15
30 30	36 3B	38 3B	16 17	33 33	41 3B	3D 3B	1A 19	30 30	3B 3B	3B 3D	18 19	35 33	3B 3E	41 3F	19 19
33 33	3B 3E	3D 3F	18 19	33 35	3E 3B	3F 3D	1A 19	30 30	39 39	3D 3B	19 18	30 30	36 36	3B 3B	18 18
30 33	39 41	3B 3F	19 1A	33 33	3E 3E	3F 3F	19 1A	33 35	41 43	3F 41	1B 1B	35 3B	43 43	43 43	1B 1B
35 35	41 3E	41 3D	19 19	33 33	3B 3B	3B 3D	18 18	35 33	41 3E	41 3F	1B 19	35 35	3E 41	41 3F	1B 1A
30 2D	3B 36	38 34	18 17	2D 30	36 36	36 38	18 17	33 30	39 39	38 38	19 18	30 33	3B 3E	3B 3D	19 1B
33 35	3E 3E	3F 41	1A 1A	35 35	3E 3E	3F 3F	19 1A	35 35	41 41	3F 3F	18 1A	35 33	3E 3B	3F 3D	19 18
33 30	39 36	3B 38	18 18	30 33	39 3B	3D 3D	18 19	35 38	41 43	3F 43	1B 1C	35 3B	41 41	43 3F	1B 1B
38 33	43 41	41 3D	1B 19	33 30	3B 39	3B 3B	18 18	30 33	39 3B	3B 3D	18 19	33 35	41 41	41 3F	19 19
33 33	3B 3B	3B 3B	19 19	30 30	39 36	3B 3B	18 18	33 33	3B 3B	3D 3B	19 18	30 35	39 3E	3B 3F	17 1A
38 33	41 39	41 3B	1A 17	30 30	36 39	36 36	17 17	33 35	39 3E	36 3D	18 19	3E 30	44 31	43 38	1B 19
1D 1C	18 16	28 22	14 10	20 22	1B 1D	20 1F	0D 0C	22 20	1D 1B	1B 1C	0A 0B	1D 24	1A 23	25 32	1D 16
20 1C	1D 16	32 32	1A 1A	1C 1B	18 16	2F 32	19 19	1B 1B	15 14	2E 2E	18 18	1B 1D	15 1B	2B 2B	17 16
22 24	23 28	2E 2F	15 16	29 29	2D 30	34 36	17 18	22 1D	23 1A	2F 28	15 13	20 22	1D 23	28 28	13 14
22 20	23 1F	2B 2E	14 15	1D 1C	1A 1A	2B 2B	15 16	1B 1B	16 16	28 26	13 12	1B 1C	16 18	23 25	12 12
1C 20	1B 1D	25 28	12 12	1D 20	1B 1B	26 26	12 13	20 22	1F 1D	2A 2A	13 13	20 1C	1D 18	28 25	12 13
1B 19	16 15	26 1F	14 0E	20 2B	1F 31	26 36	11 16	20 29	1D 28	36 38	1B 1B	35 35	41 43	41 43	1B 1C
3B 3B	43 44	48 4A	1D 1F	33 2D	3E 36	41 3B	19 17	24 1B	23 15	34 2A	19 16	22 30	22 36	2F 3B	16 18
33 35	3E 41	41 43	1A 1B	35 33	41 41	43 41	1C 18	33 33	3E 3E	3F 3B	1B 1A	35 35	3E 41	41 43	1B 1B
35 35	41 3E	41 41	1A 1B	33 33	3E 3E	3F 3F	1A 1A	33 33	3E 3E	3D 41	1A 1B	33 33	3E 3B	3F 43	1B 1A
33 33	3E 3E	41 3F	1A 1A	33 30	3B 3B	3F 3D	1A 19	30 33	3B 39	3D 3D	19 19	30 30	39 39	3D 3D	19 19
2D 30	39 39	38 3D	19 19	30 30	39 38	3D 3D	19 19	30 33	3B 3E	3F 3F	1A 1A	35 33	3E 3E	3D 3F	1A 1A
33 33	3B 3E	3F 3D	1A 19	33 33	3B 3B	41 3B	1A 18	33 33	3B 3B	3B 3D	19 19	33 30	39 36	3B 3B	19 19
33 35	3E 41	3D 41	19 1B	38 3B	44 4A	43 48	1D 1E	33 33	41 3E	3F 3F	1A 1A	33 33	3B 3E	41 3F	1A 1B
30 33	3B 3B	3D 3D	1A 1B	30 33	3E 3E	3D 3F	1A 18	33 33	3B 3E	3F 41	18 1C	33 35	41 43	43 3F	1C 1C
35 35	43 43	43 45	1D 1C	35 35	43 43	45 48	1D 1D	35 38	43 43	45 43	1C 1C	35 35	43 44	43 48	1D 1E
35 38	44 43	48 4A	1E 1D	38 38	44 4A	4A 4A	1E 1E	38 35	44 43	4A 43	1F 1D	33 33	43 41	43 41	1D 1C
35 38	43 4A	45 4F	1D 1F	38 38	4A 44	4A 48	1E 1E	3B 38	44 4A	48 4A	1F 1F	3B 3B	4A 4A	4F 4F	20 1F
3E 3E	4C 4C	4F 4F	20 20	3E 3E	50 50	50 50	20 21	3E 3B	4C 4C	4F 50	20 20	3E 3E	50 54	4F 50	20 20
3E 3F	50 50	50 50	21 21	3E 3E	50 50	50 52	21 21	3E 3E	50 54	50 52	21 21	3E 3B	50 50	50 4F	21 21
3B 3B	4C 4C	4F 4F	20 20	38 38	4A 44	4C 48	1F 1E	35 38	44 4A	48 4C	1D 1E	3B 3B	4C 4A	4C 4C	20 20
38 35	44 43	4A 48	1F 1E	35 33	41 41	45 41	1C 18	30 33	3E 3E	41 41	1B 1B	30 33	3E 3E	3D 3D	1B 18
33 33	3E 43	3F 43	18 1D	35 35	44 44	45 45	1E 1D	33 30	41 3E	41 3D	18 1A	30 30	3E 39	3D 3B	1A 19
30 33	3B 41	3B 43	1A 1B	33 33	41 41	43 41	1B 1C	33 33	41 43	43 45	1C 1D	33 33	41 43	45 43	1D 1E
33 33	4A 4A	4A 4A	1E 1E	35 35	44 43	45 48	1E 1E	35 35	44 44	48 4A	1E 1E	35 35	44 44	4A 4A	1F 1E
35 35	44 43	48 45	1D 1D	35 35	43 44	45 45	1E 1D	38 35	44 41	43 45	1E 1D	33 33	43 43	45 43	1D 1D
33 33	41 41	41 45	1C 1D	33 30	41 3E	43 41	1B 1B	30 33	41 41	41 3F	1C 1B	30 30	3E 3E	41 41	1B 1B
2D 30	3E 41	43 43	1C 1C	30 30	41 41	43 41	1C 1C	33 33	41 41	41 43	1C 1C	30 33	41 3E	3F 3F	1C 1B
33 33	3E 3E	3F 3F	1A 1C	30 30	41 3E	3F 3F	1B 1B	30 30	3E 3E	41 3F	1B 1A	30 30	3E 3E	3F 41	1B 1B
30 33	3E 41	41 43	1B 1C	33 33	43 43	45 43	1D 1D	33 30	43 41	43 43	1D 1C	30 30	3E 3E	43 41	1C 1C
30 30	3E 3E	41 3F	1B 1B	30 33	3E 3E	41 41	1B 1B	30 33	3B 3E	41 43	1B 1B	30 30	3E 3E	3F 3F	1B 1B
30 33	41 41	41 41	1C 1B	30 30	3E 3B	41 3F	1A 1B	30 30	3E 3E	3D 41	1B 1B	30 30	43 41	41 3F	1B 1B
30 30	3E 3E	3F 41	1B 1B	30 30	3E 3E	41 41	1A 1B	30 30	3E 3E	3F 3F	1A 1B	30 2D	3E 3E	3D 3D	1B 1B

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

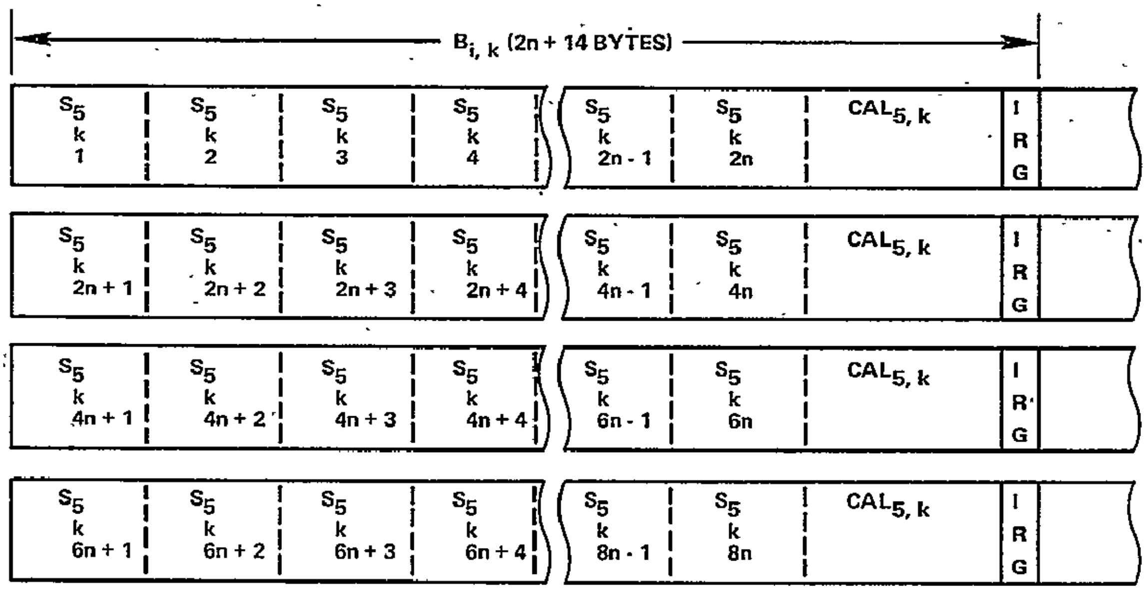


Figure 17. Bulk MSS Full Scene Fifth-Band (Band 8) Data Record

Missing Data Flags

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

Line Set

The line set ($L_{i,p}$) is the scheme used for including the video data from the fifth band which is planned for Landsat-C. A line set consists of three regular video data records and a fourth special record which contains the fifth band's video and cal data. Figure 18 is a diagram of the line set. For Landsat-1 and -2 there is no fourth record—just the regular video data records.

SIAT Data File

This file, shown in Figure 20, consists of seven records. The first record is a 2048 byte record which contains the SIAT logical tape header. The second record contains 216 bytes of Processing Information Data. The third record contains 204 bytes of Spacecraft and Sensor Performance Data. The fourth record contains 144 bytes of Annotation Block Data (Table 2). The fifth record contains 76 bytes of RBV Computational Data. Record six contains 326 bytes

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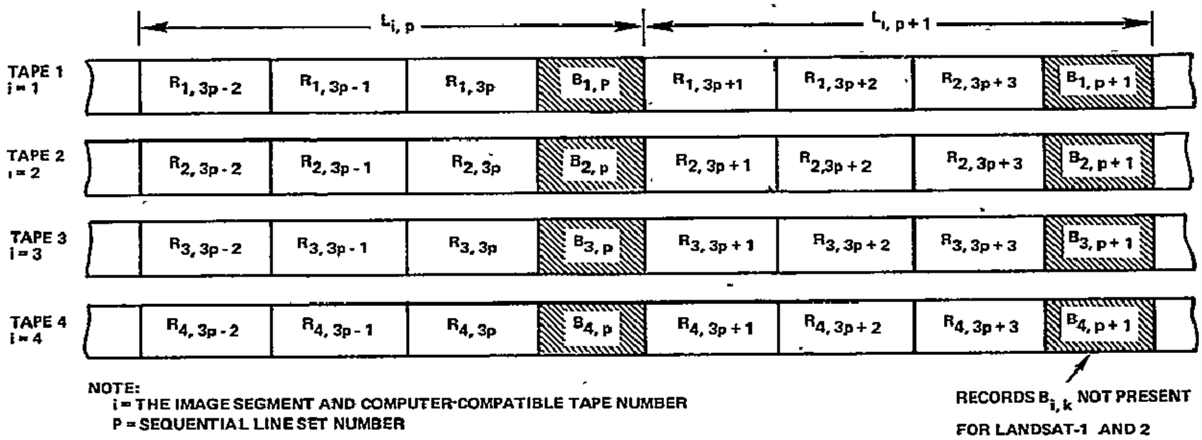


Figure 18. Bulk MSS Full Frame Line Set, With Fifth Band

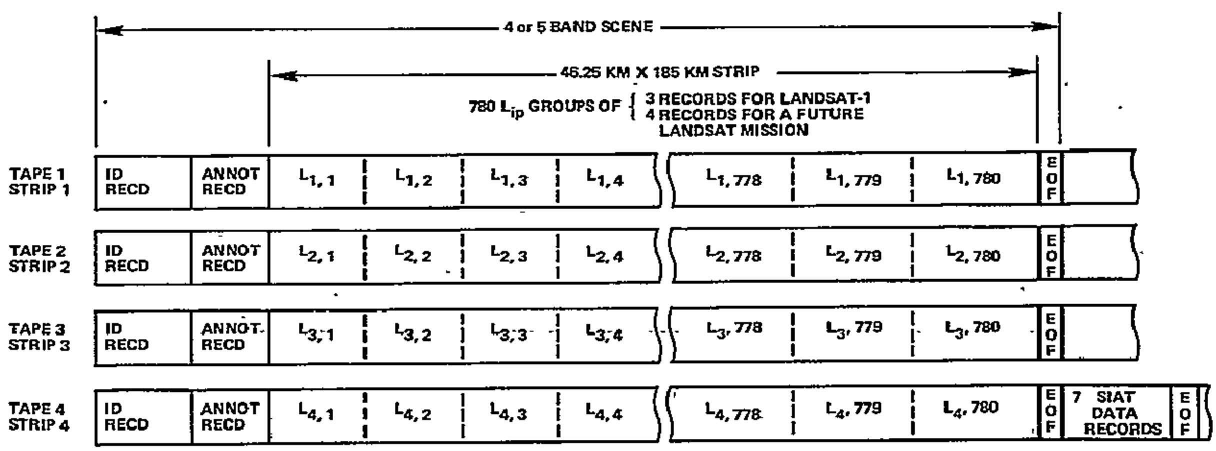


Figure 19. Bulk MSS Full Scene, Four-CCT Format

of MSS Computation Data. The seventh 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.

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

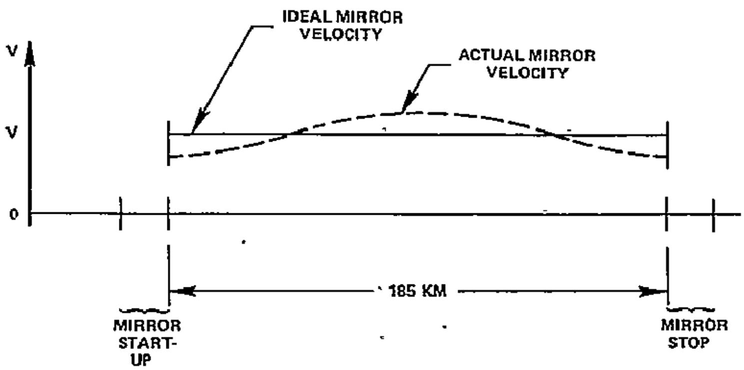
DISTANCE BETWEEN MSS CCT VIDEO DATA BYTES AND THE CORRESPONDING GROUND AREA COVERED*

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.

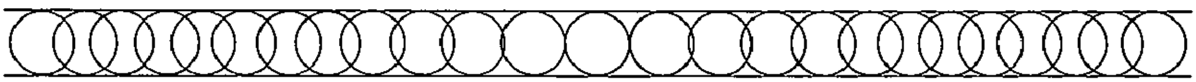
Figure A-4 shows a mirror velocity profile curve which plots the summation of the ground error versus the 185 km of ground covered. The maximum accumulated error is approximately ±400 meters (i.e., approximately 1300 feet, which is about 5 pixels). It should be noted that the mirror velocity profile 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 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.

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



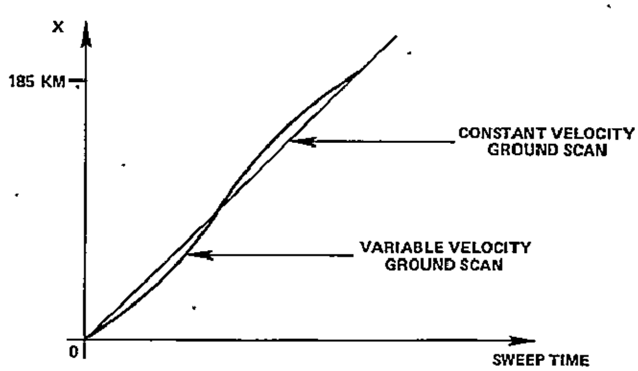
NOTE: Not drawn to scale

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

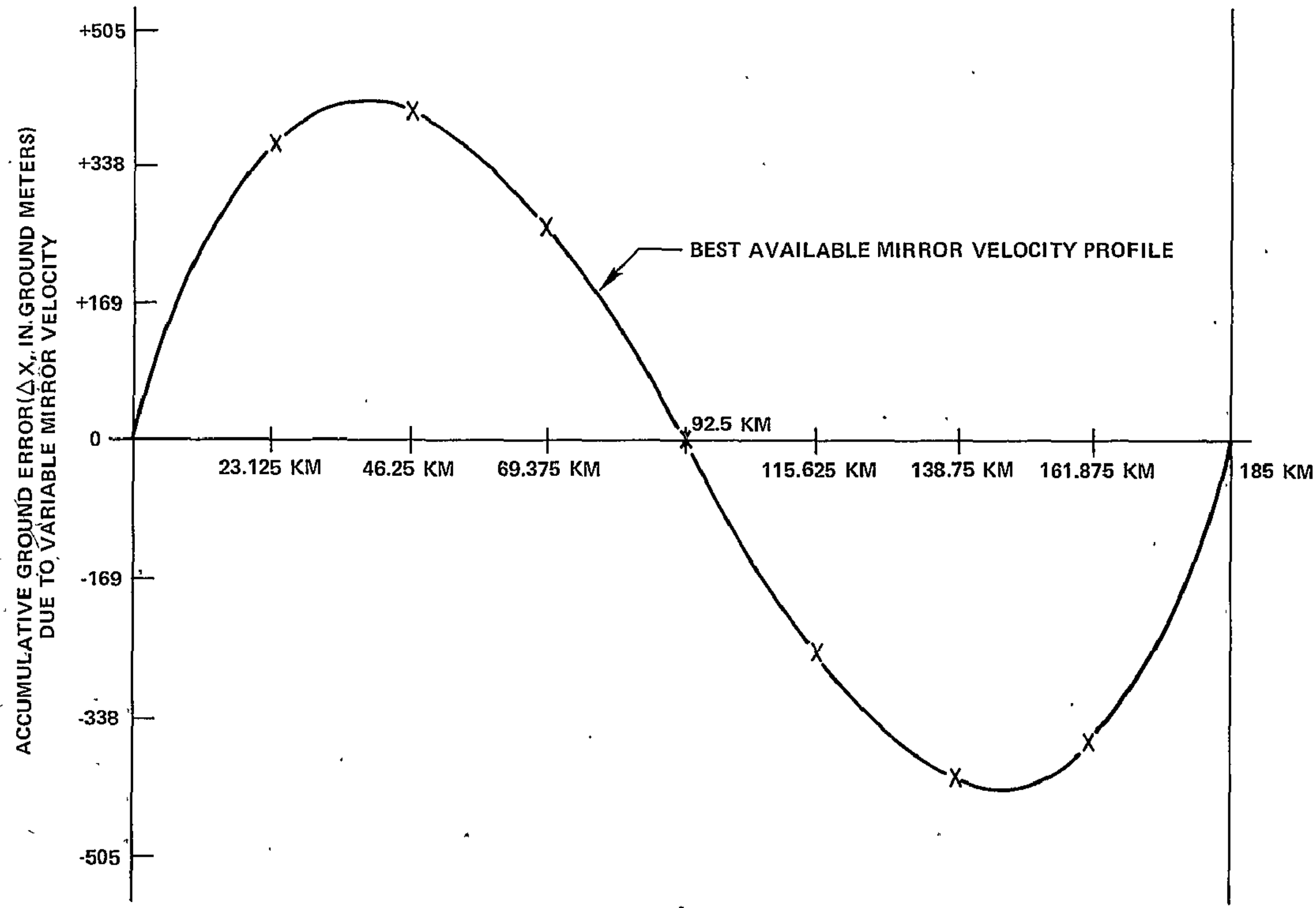


Figure A-4. Mirror Velocity Profile for the Active Mirror Scan

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

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.

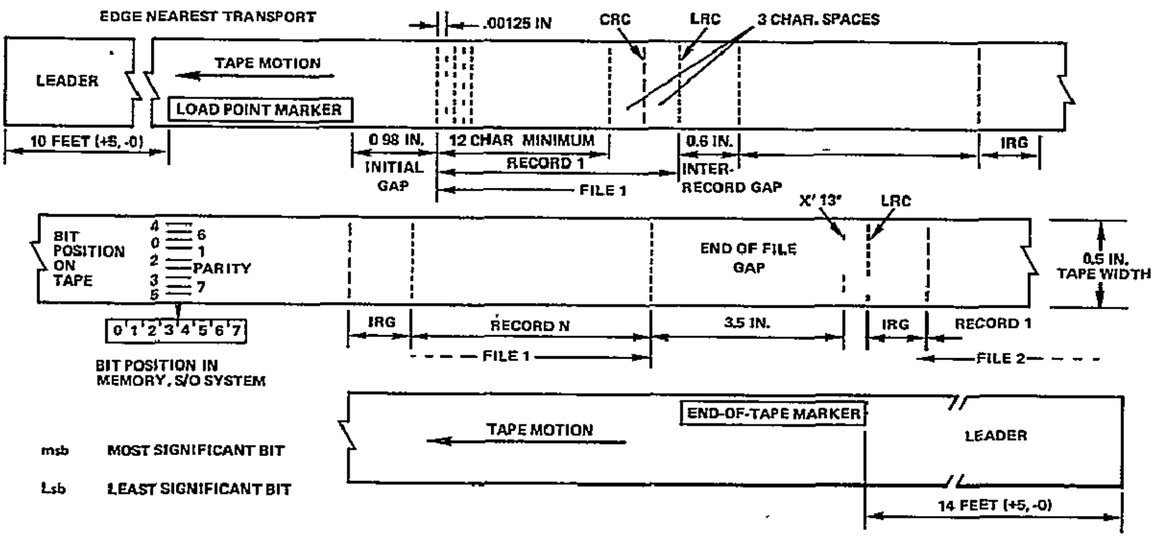


Figure B-1. Physical Spacing of Records on Tape

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.
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.

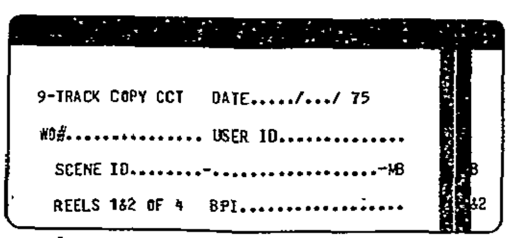


Figure B-2. External Tape Label

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 stored on an auxiliary paper tape (APT) which is 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:

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

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.,

$$\Delta \text{ initial} = \Delta - \Delta b$$

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 rediometric calibration wedge samples. The HDDT is the input to the DS. The DS reformats the data, calibrates the data and generates the CCT.

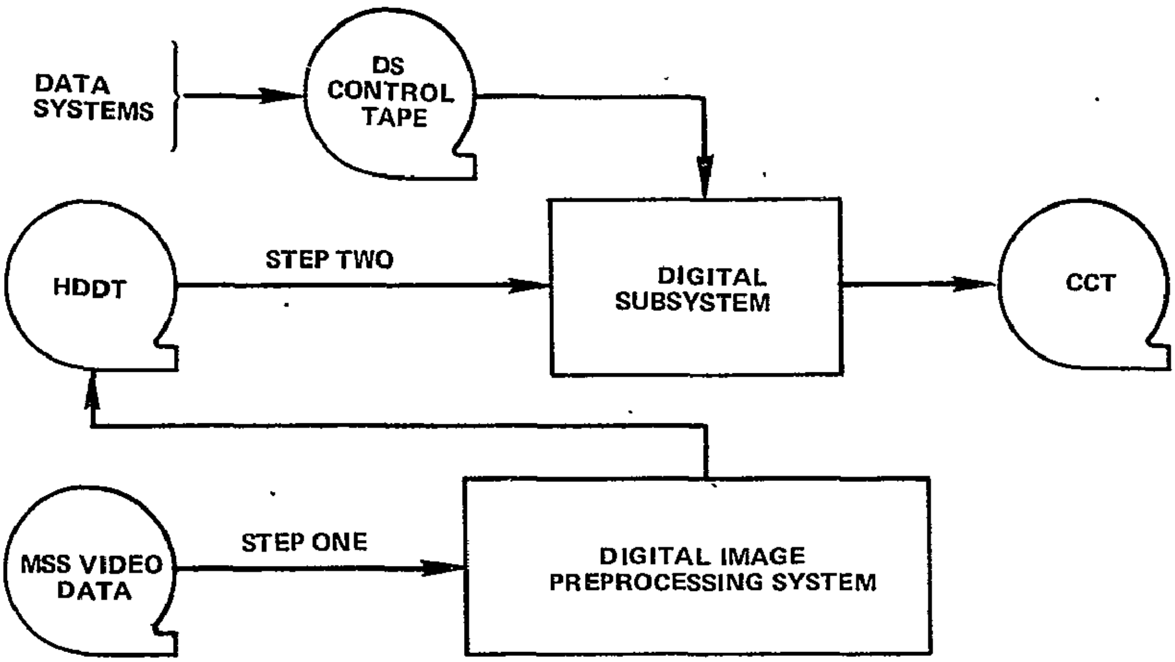


Figure D-1. Data Flow through IIGS and DS

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 rediance 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:

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

and

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

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:

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

K_S is the sun cal coefficient and U is the gray scale level (0 to 63).

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.

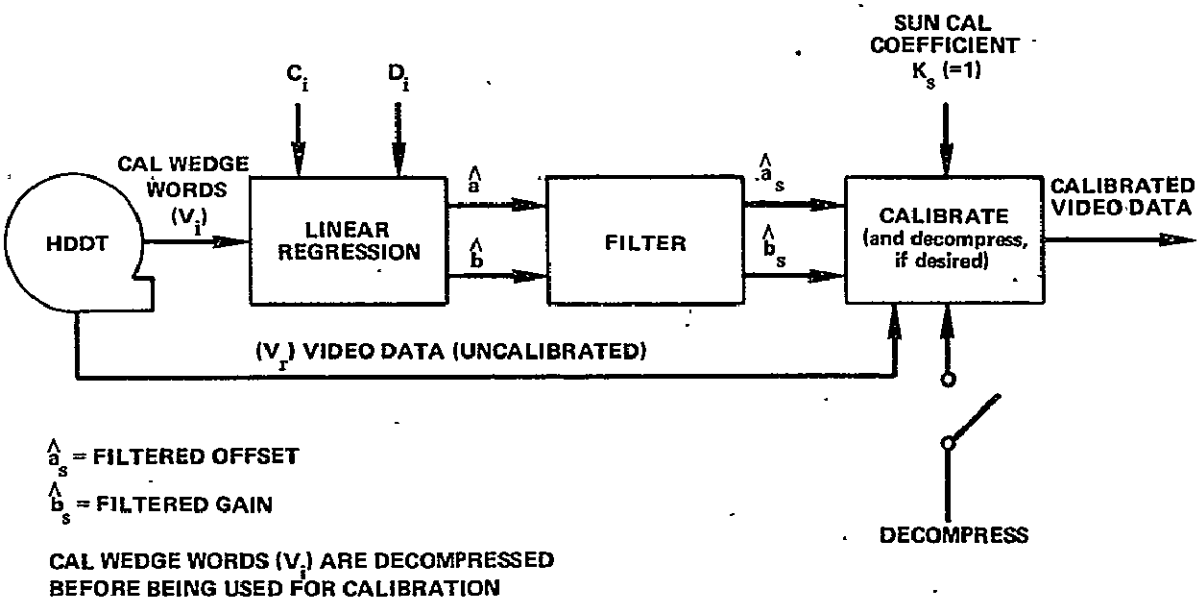


Figure D-2. DS Radiometric Calibration Flowchart

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	.216309	-.601807	.274658	-.688477	.294922
2	1.047363	-.188477	.862793	-.114258	-.251709	.332764	-.357422	.375244	-.606934	.475342	-.694092	.510254
3	1.116943	-.140137	.913574	-.084961	-.273926	.237061	-.383301	.266602	-.640869	.336426	-.732178	.361328
4	1.009521	-.131592	.826172	-.077393	-.250244	.240479	-.348877	.269775	-.578613	.337646	-.657471	.360840
5	1.096191	-.140869	.894043	-.083740	-.273193	.246582	-.378906	.276611	-.625732	.346436	-.712158	.370850
6	1.114258	-.171387	.914551	-.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	.784180	-.093506	-.296143	.324219	-.374268	.354492	-.557861	.425293	-.647705	.460205
Band 6												
13	1.118652	.629883	.769043	.247070	.240479	-.331787	-.647949	-1.305176	-.703125	-1.365723	-.777100	-1.446777
14	1.104980	-.008057	.773437	-.003174	.259521	.003906	-.647705	.017090	-.706055	.018066	-.784424	.019043
15	1.146484	-.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	.284668	.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	-.083984	.583496	.034180	-.984863	.389893	-1.079834	.411377	-1.157471	.428955
20	1.715088	-.184326	1.236816	-.086426	.652832	.032959	-1.101562	.392090	-1.207764	.413818	-1.294922	.431641
21	1.628174	-.181885	1.169189	-.083496	.610840	.035645	-1.043701	.389893	-1.142090	.411133	-1.222656	.428223
22	1.874512	-.177490	1.369141	-.084717	.743652	.030029	-1.212646	.389160	-1.336426	.411865	-1.438477	.430664
23	1.934570	-.171631	1.399902	-.078125	.744385	.036377	-1.245605	.384521	-1.366943	.405518	-1.466309	.423096
24	1.704102	-.170898	1.218018	-.074707	.629395	.041748	-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	.678467	-1.642578	.945557
2	.000000	.000000	.000000	.000000	1.689697	- .525391	.898193	- .113037	- .967773	.859131	-1.620117	1.198730
3	.000000	.000000	.000000	.000000	1.855469	- .408936	.987061	- .103027	-1.058350	.617187	-1.783936	.872803
4	.000000	.000000	.000000	.000000	1.625488	- .282715	.855957	- .058350	- .932861	.462891	-1.548584	.642578
5	.000000	.000000	.000000	.000000	1.839844	- .386963	.972656	- .092629	-1.052002	.594971	-1.760498	.835693
6	.000000	.000000	.000000	.000000	1.757324	- .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	1.085937
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	1.010742	- .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	.837646

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	.265625	- .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	.045410	- .225586	.262451	- .630859	.434326	- .874756	.537598
6	.892334	- .225098	.511475	- .057861	.268799	.048584	- .218262	.262695	- .609619	.434570	- .843994	.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	-1.130859	.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	-1.114990	.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	C_3	D_4	C_4	D_5	C_5	D_6	C_6
Band 4												
1	1.124023	-.120850	.710205	-.046143	.031738	.076416	-.238770	.125244	-.658203	.201172	-.968018	.257324
2	1.268066	-.158691	.786377	-.057861	.040283	.098145	-.269287	.163086	-.734131	.260498	-1.090332	.334961
3	1.088379	-.174561	.720459	-.077148	.045166	.101562	-.212646	.169922	-.654053	.286865	-.986572	.375000
4	1.113770	-.168213	.760010	-.078613	.050537	.100342	-.211426	.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	-.661865	.252441	-.985596	.326172
Band 5												
7	1.049561	-.053711	.735107	-.025635	.073975	.032715	-.256592	.062256	-.656494	.097656	-.944824	.123291
8	1.221924	-.089600	.872559	-.045898	.036621	.058594	-.276367	.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	.198730
11	.938721	-.094727	.672607	-.048828	.065918	.055176	-.231689	.106445	-.586914	.167725	-.858643	.214600
12	.975586	-.149902	.689941	-.074707	.058105	.090332	-.238037	.168213	-.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	.766602	-.051758	.022949	.060059	-.251953	.101807	-.713379	.171387	-.955811	.207764
15	1.133545	-.135010	.787598	-.069824	.025146	.072998	-.240723	.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	.500244	-1.077148	.922363	-1.823730	1.354980
21	1.468262	-.490479	.944336	-.245361	.330078	.041504	-.266113	.321045	-.898926	.616943	-1.676660	.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	-.263916	.352539	.066895	-.296143	.377686	-1.002197	.713867	-1.714844	1.056885

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 decompresion.

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 on 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.

APPENDIX E (continued)

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.

APPENDIX E (continued)

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.

APPENDIX E (continued)

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.

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.

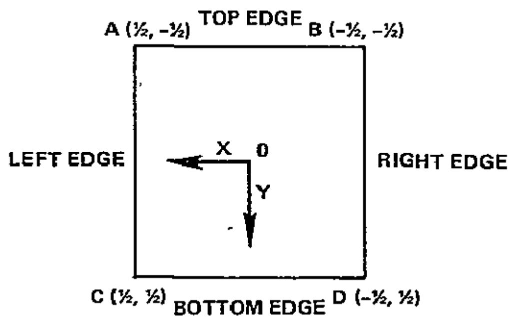


Figure F-1. Tick Mark Reference System

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.

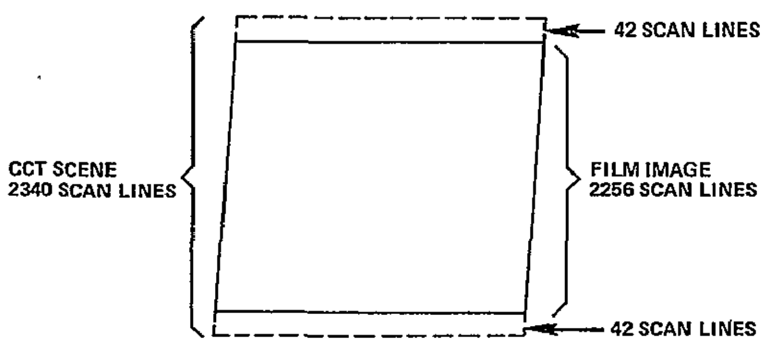


Figure F-2 CCT and Film Image Comparison

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

APPENDIX G (continued)

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

APPENDIX G (continued)

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

APPENDIX G (continued)

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	.55859 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	63 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	39843 75000	.A6 00 00 00	64843 75000	.E6 00 00 00	.89843 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	.41015 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	.23437 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

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APPENDIX G (continued)

Hexadecimal	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	00302 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
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.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
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.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

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Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal	Hexadecimal	Decimal
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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 00023	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
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.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
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.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
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.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 00533
.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	8	SIAT Number	EBCDIC (TTADDDNN)
9	1Ø	Date of Tape Preparation	EBCDIC (ƀDDƀMMMƀYY)
19	1Ø	ZERO	BINARY
29	8	SIAT Number	EBCDIC (TTADDDNN)
37	8	RBV Tape Number	EBCDIC (TTADDDNN or blanks)
45	8	MSS Tape Number	EBCDIC (TTADDDNN or blanks)
53	2	Number of Data Files on Logical SIAT	INTEGER
55	2	ZERO	BINARY
57	2	ZERO	BINARY
59	2	Number of RBV/VTC	INTEGER
61	2	Number of MSS/VTC	INTEGER
63	2	Number of RBV/TFC	INTEGER
65	2	Number of MSS/TFC	INTEGER
67	2	ZERO	BINARY
69	2	1st-64th RBV Scene ID's	EBCDIC ADDD-HHMMSƀƀ
837	768	1st-64th MSS Scene ID's	EBCDIC ADDD-HHMMSƀƀ
16Ø5	444	ZERO	BINARY

Table H-2
Processing Instruction Data
Record 2

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	10	Scene ID	EBCDIC nddd-hhmms
23	10	Preceding Closest RCI ID From W.O.	EBCDIC nddd-hhmms
33	10	Succeeding Closest RCI ID From W.O.	EBCDIC nddd-hhmms
43	1	Mission No. (1 or 2)	Binary
44	1	Day Number From Launch	Binary (most significant part; least signif. bit is 2^6)
45	1	Day Number From Launch	Binary (6-bit least signif. part; 6 bits avail.)
46	1	Hours of Day	Binary
47	1	Minutes of Hour	Binary
48	1	Tens of Seconds	Binary
49	2	Not Used	Binary Zero
51	8	Band 1 Information from PIAT W.O.	EBCDIC 1aaaaabb
59	8	Band 2 Information from W.O.	EBCDIC 2aaaaabb
67	8	Band 3 Information from W.O.	EBCDIC 3aaaaab
75	8	Band 4 Information from W.O.	EBCDIC 4aaaaaab
83	8	Band 5 Information from W.O.	EBCDIC 5aaaaaab
91	8	Band 6 Information from W.O.	EBCDIC 6aaaaaab

Table H-2 (continued)
Processing Instruction Data
Record 2

Starting Byte No. and Length (Bytes)		Information	Format
99	8	Band 7 Information from W.O.	EBCDIC 7aaaaabb
107	8	Band 8 Information from W.O.	EBCDIC 8aaaaabb
115	72	Special Instructions to Precision Processing Operator from W.O.	EBCDIC
187	1	Mission No.	Binary
188	1	Day No. From Launch	Binary (most signif. part; least signif. bit is 2^6)
189	1	Day No. From Launch	Binary (6-bit least signif. part; 6 bits avail.)
190	1	Hours of Day	Binary
191	1	Minutes of Hour	Binary
192	1	Tens of Seconds	Binary
193	1	Not Used	Binary Zero
194	1	Not Used	Binary Zero
195	6	Output Frame ID	Same as Item 38
201	1	Not Used	Binary Zero
202	1	Not Used	Binary Zero
203	2	Processing Code from SIAT Generation Work Order	Binary
205	2	Processing Code for MSS	Binary
207	2	Polar Stereo Projection	HEXADECIMAL
209	8	FLAG	Binary Zero
216	Total Bytes		

Inter-Record Gap

Table H-3
Spacecraft Performance Data
Record 3

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 Sperture 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 MSSb4bbbbbab
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 respect., 1=high Bits 3-16 are zero
99	1	MSS Sensor Encoding	Binary, bits 1-3, for bands 4-6 respect. 1=compressed. Bits 4-8 are zero
100	1	Not Used	Binary Zero
101	8	SPDT Tape ID	EBCDIC SPndddnn
109	4	MSS SUN CAL DAY	EBCDIC OODDD
113	48	MSS SUN CAL's SENSORS 1-24	Binary Scaled 2^{-12}

Table H-3 (Continued)
Spacecraft Performance Data
Record 3

Starting Byte No.	and Length (Bytes)	Information	Format
151	36	Not used	Binary Zero
197	4	MSS SUN CAL DAY desired	EBCDIC 'bbb' 'Fill' or 'BADb'
201	4	MSS SUN CAL FLAG	EBCDIC 'DDD'
204	Total Bytes		

Inter-Record GAP

Table H-4
Annotation Block Data
Record 4

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 of Format Center	annn-nn
25	3	Constant	bNb
28	6	Latitude of Nadir	ann-nn
34	1	Constant	/
35	8	Longitude of Nadir	annn-nnb
43	12	Blank Field 1	blanks
55	8	Sun Elevation at Nadir (Deg)	SUNbELnn
63	6	Sun Azimuth at Nadir (Deg)	bAZnnn
69	4	Satellite Heading (Deg)	bnnn
73	6	Rev. Number	-nnn-
79	4	RBV Data Acquisition	a-1-
83	2	Blank Field 2	bb
85	2	Type of Orbit Data (Pred. or Defin.)	a-
87	2	Blank Field 5	bb
39	13	Constant	bNASAbERTSbE-
102	10	Scene Identification	nddd-hhmms
112	1	Constant	-
113	1	Blank Field 3	b

Table H-4 (Continued)
Annotation Block Data
Record 4

Starting Byte No. and Length (Bytes)		Information	Format
114	1	RCI Images Calibration Level	EBCDIC n (or blank)
115	2	Blank Field 4	bb
117	5	RBV 1 Mode (Direct or Recorded)	1bbaX (or blanks)
122	2	RBV 1 Shutter Setting, Aperture Correction Indicator	aa (or blanks)
124	6	RBV 2 Mode	bb2baX (or blanks)
130	2	RBV 2 Shutter Setting, Aperture Correction Indicator	aa (or blanks)
132	6	RBV 3 Mode	bbb3aZ (or blanks)
138	2	RBV Shutter Setting, Aperture Correction Indicator	aa (or blanks)
140	5	MSS Mode (Direct or Recorded) and Acquisition Site	baba- (or blanks)
144	Total Bytes		

Inter-Record GAP

Table H-5
RBV Computational Data
Record 5

Starting Byte No. and Length (Bytes)		Information	Format
1	8	Spacecraft time of Exposure	4-bit BCD OOOOOdddhhmmsscc
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 bddbmmmbyy
29	8	GMT Time of Exposure	EBCDIC bhhmm:ss
37	4	Latitude of Format Center	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} Rad.)	Binary
65	4	Pitch (10^{-6} Rad.)	Binary
69	4	Roll (10^{-6} Rad.)	Binary
73	4	Yaw (10^{-6} Rad.)	Binary
76	Total Bytes		

Inter-Record Gap

Table H-6
MSS Computational Data
Record 6

Starting Byte No. and Length (Bytes)		Information	Format
1	8	Spacecraft Time of Scene Center	4-bit BCD OOOOOdddhhmmsscc
9	8	GMT of Scene Center	4-bit BCD OOOdddhhmmssmmmO
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, respectively	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, respectively	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, respectively	Binary fraction, 2 bytes per value
95	2	Yaw at Time of Item 102 (Rad.)	Binary fraction

Table H-6 (Continued)
MSS Computational Data
Record 6

Starting Byte No. and Length (Bytes)		Information	Format
97	16	8 Values of Yaw at the Times of Items 102 - 110, respectively	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
137	4	Mean Yaw Rate (10^{-6} Rad/Sec.)	Binary
141	4	Meal 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

Table H-6 (Continued)
MSS Computational Data
Record 6

Starting Byte No. and Length (Bytes)		Information	Format
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

Table H-7
Image Location Data
Record 7

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		

END OF FILE

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 have 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 Figures 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												
REGION 1	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0
REGION 2	41.6	42.2	41.4	42.0	40.8	40.4	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	11.8	11.7	12.0	11.5	12.1	11.9	15	15	15	15	15	15
REGION 2	45.2	44.9	44.9	44.2	44.3	44.7	50	50	50	50	50	50
REGION 3	69.0	68.8	67.9	67.4	67.8	68.9	47	47	47	47	47	47
BAND 3												
REGION 1	8.9	9.1	8.9	7.4	7.7	8.2	18	18	18	18	18	18
REGION 2	43.1	43.1	43.7	42.9	43.6	43.6	50	50	50	50	50	50
REGION 3	74.2	79.3	75.7	71.3	78.0	74.6	15	15	15	15	15	15
BAND 4												
REGION 1	12.9	12.9	12.7	12.7	12.7	12.7	50	50	50	50	50	50
REGION 2	23.2	23.2	23.3	23.3	23.7	23.2	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

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

	AVR RADIANCE LEVEL FOR EACH DETECTOR 1	2	3	4	5	6	NO. OF SAMPLES FOR EACH DETECTOR 1	2	3	4	5	6
BAND 1												
REGION 1	17.1	16.9	16.6	16.9	17.1	16.2	17	17	17	17	17	17
REGION 2	33.7	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	14.4	14.5	14.0	14.1	14.3	14.0	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	14.0	14.5	14.2	14.1	13.2	13.9	44	44	44	44	44	44
REGION 2	36.1	37.8	38.3	38.1	38.0	37.5	50	50	50	50	50	50
REGION 3	76.8	77.9	77.6	77.1	78.3	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	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0

STOP 0

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