ESA/EARTHNET

LANDSAT
THEMATIC MAPPER (TM)
CCT FORMATS STANDARDS

CST 550
REVISION 2
OCTOBER 1987

Produced at the Manchester Computing Centre in accordance with an agreement between the Combined Higher Education Software Team (CHEST) and National Remote Sensing Centre Ltd. (NRSC).

ESA/EARTHNET

LANDSAT
THEMATIC MAPPER (TM)
CCT FORMATS STANDARDS

CST 550
REVISION 2
OCTOBER 1987

Produced at the Manchester Computing Centre in accordance with an agreement between the Combined Higher Education Software Team (CHEST) and National Remote Sensing Centre Ltd. (NRSC).

Preface to the Manchester Reprint

This document is a striaght reprint of the manual produced by National Remote Sensing Ltd. (NRS), of Delta House, Southwood Crescent, Southwood, Farnborough, Hampshire, GU14 ONL, U.K.

We are grateful to NRS for permission to reproduce this manual for the higher education and research community in the U.K.

Reprinted at the Manchester Computing Centre, University of Manchester.

ESA/EARTHNET

LANDSAT

THEMATIC MAPPER (TM)

CCT FORMATS STANDARDS

OCTOBER, 1987
EPO/84-557
REVISION 2

BACKGROUND

This new revision of the Landsat TM CCT Format Standards has been produced for two main reasons:
- to describe features that have been changed or added to the digital product since last revision of this document (e.g. Calibration Volume)
- to introduce a new standard to represent the description, explanation and content of each record on the CCT. The records are presented as a table in the sequence they appear for the first time on the tape, and all the information concerning each field is grouped allowing easy comparison between format and real data.

Any inaccuracies or problems encountered by the users should be reported to:

Pascal GILLES
Quality Control Service
E.P.O.
ESRIN Via Galileo Galilei I 00044 Frascati

TABLE OF CONTENT

RECORD OF REVISION

rev	issued	inserted	by
1	MAY 84		
2	OCTOBER 87	FULL TEXT	P.GILLES

CHAPTER 1

INTRODUCTION

The LANDSAT System has been set up in 1972 with the launch of the LANDSAT 1 satellite which was followed by LANDSAT 2 in 1975 and LANDSAT 3 in 1978. These 3 satellites carried on board two sensors the Multispectral Scanner (MSS) and the Return Beam Vidicon (RBV). In July 1982, LANDSAT 4 was launched with ,on board, in addition to the MSS a new sensor called Thematic Mapper (TM) which transmitted data only till February 1983 due to a satellite down-link failure. A new satellite LANDSAT 5, with similar characteristics has been launched on March 1st 1984.

The ground activities of NOAA and the foreign operators of LANDSAT stations are coordinated within the LANDSAT Ground Station Operator Working Group (LGSWOG), a subgroup of which the so called LANDSAT TECHNICAL WORKING GROUP (LTWG) has developed and recommended a co-ordinated TM standard format.

Chapter 2 of this document defines the Computer Compatible Tape (CCT) format for raw or system-corrected Landsat Thematic Mapper (TM) imagery data acquired from the Landsat 4 and 5 satellites and supplied to users, by ESA/EARTHNET ground systems.

Chapter 3 contains the detailed descriptions of the volumes, files and record types used in the definition of the CCT format.

The ESA Landsat TM CCT product conforms in most of his aspects to the Standard format family as defined by the LTWG. ANNEX 1 has been used to give an overview of that family and detailed explanations of those records which are common to all members of the Standard format family.

CHAPTER 2

LANDSAT TM PRODUCT DEFINITION

2.1 LANDSAT THEMATIC MAPPER

This section to be supplied at a later date. It does not affect the format specification itself, but supplies only background information. It will contain an overview of the Thematic Mapper (TM), the Payload Correction Data (PCD) and the mission telemetry.

2.2 PRODUCT ORGANISATION

Landsat TM raw and system-corrected data are provided in CCT form recorded at either 1600 bpi or 6250 bpi, in a format conforming to the constraints of the Standard CCT family of tape formats. The recommendations of the LTWG have been followed in detail in the construction of the ESA TM CCT format.

The products consist of a full scene or one quadrant (plus overlap) of a Worldwide Reference System (WRS) scene, as recorded by one or more of the seven TM spectral bands. The WRS is an indexing system for orbits (paths) and frame centres (rows) along each of the paths. Landsat 4/5 WRS full scenes of imagery data are preset at 23.92 second increments of spacecraft time in either direction calculated from the equator,and thus correspond to a ground coverage area of approximately 185 kms wide by 160 kms in the along-track direction. A full scene product has an overlap with adjacent scenes of 6 kms at the top (northern-most data line) and at the bottom (southern-most data line), and is therefore about 183 kms wide by 172 kms in the along track direction. A product is divided into four quadrants, each containing equal numbers of lines and pixels, nominally about the WRS frame centre, where quadrant 1 contains the upper left quarter of the scene, quadrant 2 contains the upper right quarter, quadrant 3 contains the lower left quarter and quadrant 4 contains the lower right quarter of the scene. Considerable variation in the location of the nominal WRS scene centre pixel will occur due to orbital and attitude variations.
ESA full scene or quadrant will have overlaps of about three percent in the along-track direction corresponding to the 80 scan lines (5 full sweeps) from the adjacent quadrant, and one hundred pixels (3 kms) in the cross-track direction. The nominal WRS scene centre in terms of line number and pixel number will be given in the map projection record. (Since overlap areas are provided, the nominal WRS scene centre will be located in all four quadrant products).
The data organisation may be Band Interleaved by Line (BIL) or Band Sequential (BSQ). In the BIL organisation which contains only one imagery data file, the video data for one scan line for each of the requested spectral bands is grouped together BEFORE providing data for the next scan line. In the BSQ organisation, the video data for ALL scan lines of each spectral band are grouped together in one imagery data file and followed by a trailer file.

The trailer file contains scene statistics for the associated imagery data. The leader file contains scene introductory information, such as the definition of the full WRS scene of which the quadrant forms a part, processing parameters, sensor and mission definition, geographic referencing data, and the radiometric transformation tables.

2.2.1 LOGICAL VOLUME ORGANISATION

TM data products are organised into logical volumes, which can span one or more tapes (physical volumes). Although the simplest products to use will be those which occupy only one physical volume, the superstructure concepts used in the standard format family conveniently handle multiple physical volumes, with imagery data split across physical volumes either between files or between records within files. As a general rule of thumb, one scene quadrant in three spectral bands in either the BIL or BSQ organisation can be accommodated on one CCT recorded at 1600 bpi, one quadrant in all seven spectral bands can be accommodated on one CCT recorded at 6250 bpi,one full scene in three spectral bands in either BIL or BSQ organization can be accommodated on one CCT recorded at 6250 bpi and one full scene in one spectral band can be accommodated on one CCT recorded at 1600 bpi.
The raw and system-corrected Landsat TM data set as recommended by the LTWG consists of two logical volumes, namely, the imagery logical volume and the supplemental logical volume. These two volumes may be considered quite independently from each other, from both the product definition and data processing points of view, since both can exist independently as valid data sets.

Earthnet has added another logical volume, namely ,the calibration logical volume, after the supplemental logical volume and before the null volume.

2.2.1.1 IMAGERY LOGICAL VOLUME

The first logical volume, termed the imagery logical volume, contains the imagery data itself and related image-synchronized information, plus ONLY that support data related to the scene. In other words, such orbital information as ephemeris and attitude data is specifically excluded from this volume, as it is station-specific. If no supplemental information is required, then the data set may consist of an imagery logical volume only.

2.2.1.2 SUPPLEMENTAL LOGICAL VOLUME

The supplemental logical volume is defined in general terms to contain station-related processing data, such as annotation, ephemeris and attitude data, and raw or processed PCD.

The ESA supplemental logical volume consists of one data file only, whose content is raw PCD and mission telemetry data relevant to the image data supplied. The content of each PCD record is defined in relation to one major frame of PCD data, which, in turn, can be linked to the video data by means of the satellite time code. The number of PCD records included in the supplemental file is dependent on the application of the product.

2.2.1.3 CALIBRATION LOGICAL VOLUME

The calibration logical volume contains calibration data acquired from the Landsat satellites within the TM data stream. It consist of one data file that contains calibration data covering 400 TM swaths.

2.3 STANDARD FAMILY CONVENTION

The simplest general construction of one TM product occupying one physical tape only would consist of the following files:

VOLUME DIRECTORY FILE - (for imagery logical volume).
- describes relationship of this logical volume to the complete data set
- and gives details of the construction of the first logical volume.

LEADER FILE

IMAGERY FILE

TRAILER FILE

VOLUME DIRECTORY FILE - (for supplemental logical volume).
- describes relationship of this logical volume to the complete data set
- and gives details of the construction of the second logical volume.

SUPPLEMENTAL FILE

VOLUME DIRECTORY FILE - (for calibration logical volume).
- describes relationship of this logical volume to the complete data set
- and gives details of the construction of the third logical volume.

NULL VOLUME DIRECTORY - terminates the volume set.

However, when the volume set spans multiple physical volumes, specifically where one constituent logical volume spans more than one tape, the volume directory file for that logical volume is repeated at the start of the new tape. Certain fields within that file are updated to indicate, for example, the new physical volume sequence number, which file is split, and, if available, the record sequence number of the first data record on the new volume.

Figures 1 and 2 show the organization of the files in the imagery logical volume for Band Sequential (BSQ) and Band Interleaved (BIL) data respectively.

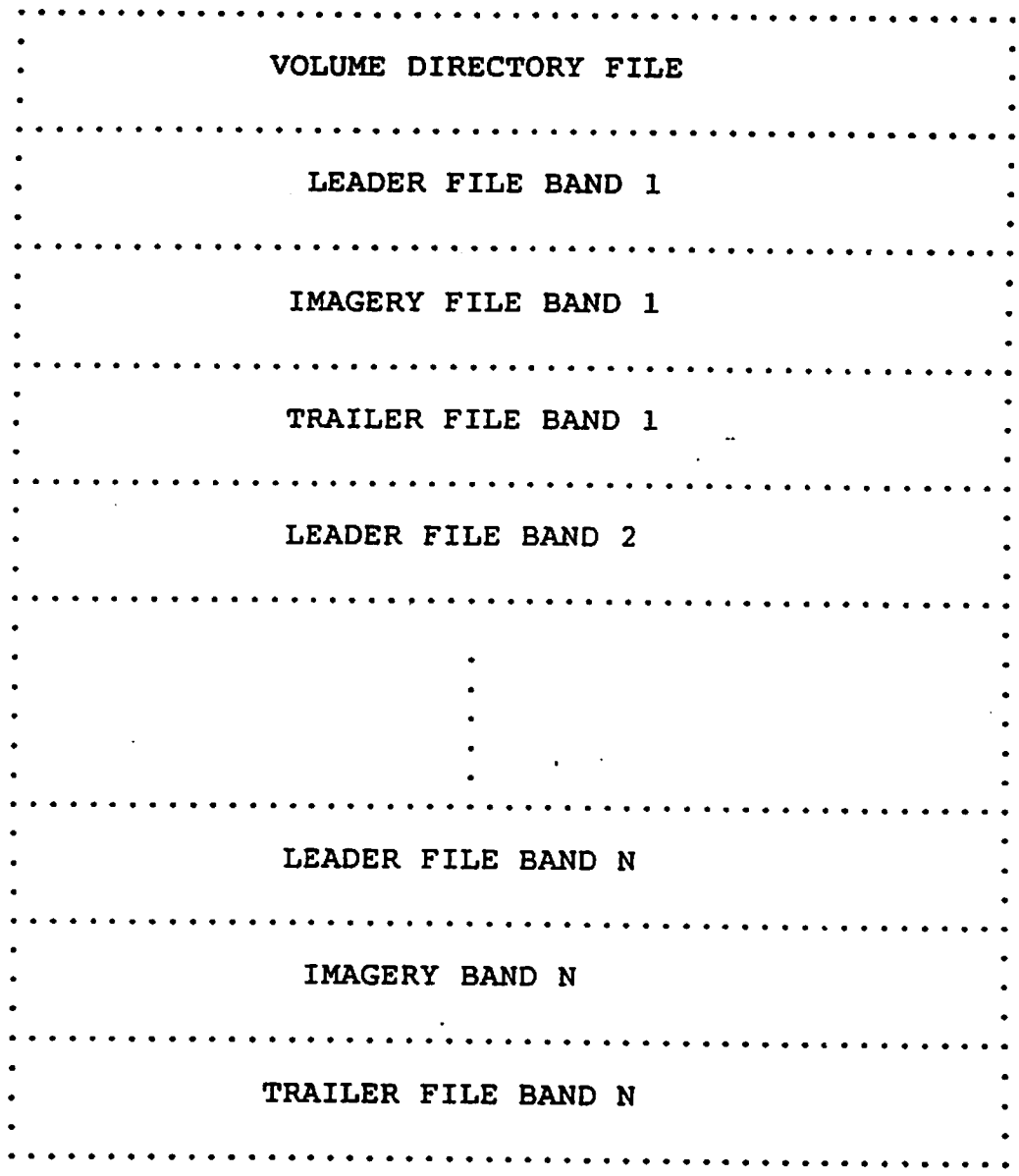


FIGURE 1
BSQ FULL OR QUARTER SCENE IMAGERY
(N CAN BE EQUAL 1 TO 7)

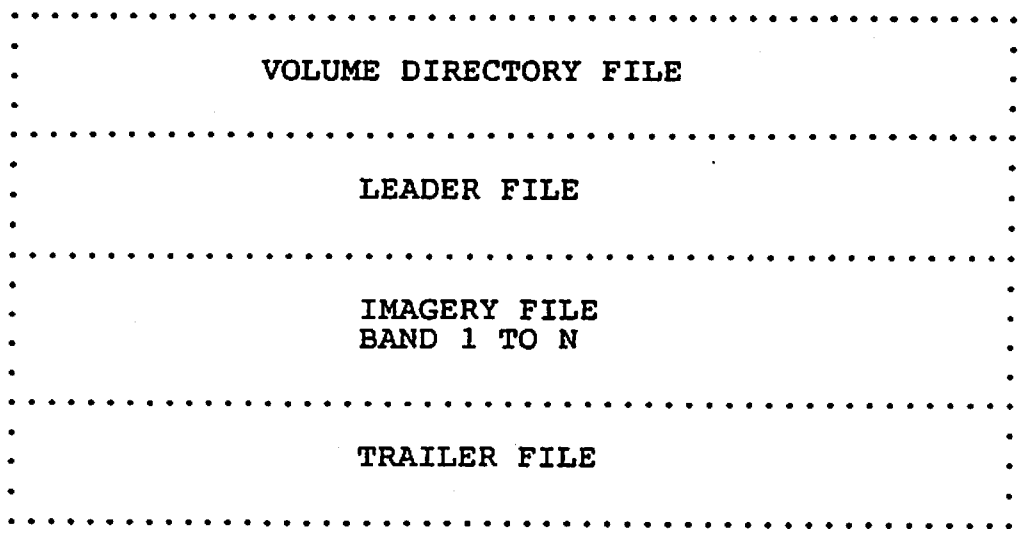


FIGURE 2
BIL FULL OR QUARTER SCENE IMAGERY
(N CAN BE EQUAL 1 TO 7)

2.4 LEVELS OF CORRECTION

Table 3 gives a generalized overview of the eleven processing levels and an open-ended set of flags designed to reflect these levels is found in the leader file scene header record. The adoption of the terminology for these processing levels is strongly recommended by the LTWG. Hence, the level of processing applied to products addressed in this document can be categorized as level 0, 1, 2, 3, 4 or 5 only.

2.4.1 RADIOMETRIC CORRECTION

Absolute radiometric calibration can be applied using the calibration data supplied in the video data stream (all bands), the calibration shutter and blackbody temperatures from the PCD (thermal band only), and prelaunch absolute calibration constants (bands 1 through 5 and 7 only). Alternatively, the absolute calibration may be performed using pre-flight calibration data only. There are processing flags in the scene header record to identify the calibration method, any sun angle illumination or haze correction and any enhancements. For radiometrically corrected products, coefficients required to convert the calibrated data to engineering units may be found in the radiometric calibration ancillary record. The calibration data is also stored in the suffix area of the video data record. Destriping may be performed using scene statistics as an integral part of the radiometric correction process.

In the case of inoperative detectors, the video data will be replaced by that for an adjacent detector, and the replacement detector will be identified in the scene header record.

2.4.2 GEOMETRIC CORRECTION

2.4.2.1 RAW PRODUCTS

Geometrically raw products contain the original TM video data samples BUT with the following corrections applied on a full scan line basis.

1) The video data for individual detectors are shifted by an integral number of pixels, on a line by line basis, to account for detector layout geometry and multiplexer sampling times. Residual sub-pixel misalignments may remain. Pixels corresponding to geographic locations NOT sampled by all detectors, on both the forward and the reverse sweeps, are discarded. (In order for forward and reverse sweeps to be nominally aligned, the start of line code for band 1 odd detectors on the forward sweep is aligned with the end of line code for band 1 odd detectors on the reverse sweep. The raw image record contains, in addition to the count of the ACTUAL number of pixels supplied in the record, the total count of pixels in the ORIGINAL full scan line. It also contains the raw line length code information required for subsequent mirror velocity profile corrections.

2) The reverse scan is inverted such that the forward and reverse scans are nominally registered.

3) The pixels for the thermal band are each replicated four times within the scan line, and full scan lines are replicated four times, such that the pixel to pixel centre spacing is nominally the same for all spectral bands.

2.4.2.2 SYSTEMATIC CORRECTIONS

The systematic corrections addressed in this document are defined as those which can be performed, using a priori information, and other auxiliary information. They involve only along scan resampling, and the resampling method is identified in the scene header record. Products so defined are of level 0, 1, 2, 3, or 4 only. They include:

1) Mirror scan velocity profile corrections using fifth order polynomials defined individually for the forward and reverse scans, together with the first half scan and second half scan error times (which are found embedded in the video data stream).

2) Earth rotation correction.

3) Panoramic distortion and earth curvature correction.

In addition, resampling in two dimensions for jitter and scan gap corrections can be accommodated within the scope of level 5 products.

2.5 PRODUCT CLASSIFICATION

2.5.1 STANDARD PRODUCT CLASSIFICATION

Products are classified according to table 3

TABLE 3

Level	Classification	Geometric	Radiometric	Resamp.	Map
0	Uncorrected	Forward/Reverse Scan Line Correction	None	None	None
1	Radiometrically Corrected	Same as level "0"	Internal Calibration/ Pre-Flight Data/ Histograms Applied/ Sun Elevation/ Film Gamma/Scenic Corrections/Histogram Mean and Standard Deviation	None	None
2	Raw Data w/ Corrections Tables	Same as Level "1" plus Detector Displays,Mirror Scan Lenght,Earth Rotation and Attitude Data	Level "1" Corrections Calculated and Appended to Data	None	None
3	Systematic	All Level "2" Corrections Calculated and Applied	None	Along Line	None
4	Systematic	All Level "2" Corrections Calculated and Applied. Gyro,ADS,ACS,Ephemeris and Scan Gap Corrections Calculated and Appended.	Level "1" Corrections Calculated and Applied to Data	Along Line	None
5	Systematic	All Level "4" Corrections Calculated and Applied	Same as Level "4"	Two-Dimensionnal	SOM OTM/ PS

Level	Classification	Geometric	Radiometric	Resamp.	Map
6	Fully Corrected Product	All Level "5" Corrections Plus GCPs Calculated and Applied to Data	Same as Level "4"	Two-Dimen-sionnal	SOM UTM/ PS
7	Fully Corrected Product	All Level "6" Corrections plus DTM Calculated and Applied to Data	Same as Level "4"	Two-Dimen-sionnal	SOM UTM/ PS
	Systematic	Same as Level "5"	Same as Level "4"	Two-Dimen-sionnal	UTM Geoc.
9	Fully Corrected Product	Same as Level "6"	Same as Level "4"	Two-Dimen-sionnal	UTM Geoc.
10	Fully Corrected Product	Same as Level "7"	Same as Level "4"	Two-Dimen-sionnal	UTM Geoc.

2.5.2 EARTHNET TM PRODUCT CLASSIFICATION

None of the products delivered by EARTHNET matches completely with one description of the standard product classification described in Table 2.1.
Therefore we have adopted following definitions :
- raw product defined as level "0"
- system corrected defined as level "5"

which are the most similar to Earthnet products

The standard system-corrected Earthnet TM product is radiometrically corrected using pre-flight data. However, one can obtain products with alternative calibration methods as shown in Table 4

TABLE 4

Level	Geometric	Radiometric
0	Forward/Reverse Scan Line Correction	None
1	Fully Corrected Product	Pre-Flight Data
2	Fully Corrected Product	Relative Data
3	Fully Corrected Product	On-Board Data
4	Fully Corrected Product	Pre-Flight plus On-Board Data
5	Fully Corrected Product	Relative plus On-Board Data

where a geometrically fully corrected product has been processed for
- forward/reverse scan line correction
- detector displays,mirror scan length,Earth rotation and attitude data
- Gyro, ADS, ACS, ephemeris and scan gap data
- along line resampling using nearest neighbour method

2.6 LANDSAT TM CCT FORMAT OVERVIEW

For an overview of the standard family of CCT formats, the reader is directed to Annex 1. In addition, that Annex also contains detailed specifications of the format of those records which are common to all standard format family implementations.

2.7 IMAGERY LOGICAL VOLUME OVERVIEW

The only file classes used for the ESA Landsat TM imagery logical volume are LEADER FILE, IMAGERY FILE and TRAILER FILE, with the corresponding four-character file class codes of LEAD, IMGY and TRAI respectively. The following sub-sections describe the file descriptor record variable segments and the constituent record types for each of the three file classes. The record types are tabulated in Table 4.1.

2.7.1 LEADER FILE

The construction of the leader file and of its constituent records has been defined in detail by the LTWG, and the ESA implementation conforms precisely to the LTWG definition. (Those fields which have been allocated by the LTWG as for local use are clearly identified as such in the appropriate record definition).

Leader files contain the following record types:

File descriptor record;
Scene header record;
Map projection (scene-related) ancillary record;
Radiometric transformation ancillary record.

All leader file records contain the standard twelve bytes of record introductory data, stored in binary, (namely, record sequence number, record type and sub-types, and record length). All leader file records are of a fixed length of 4320 bytes, and contain fields recorded as alphanumeric or numeric strings coded in ASCII or recorded as 8-bit binary bytes.

2.7.1.1 LEADER FILE DESCRIPTOR VARIABLE SEGMENT

The leader file variable segment gives the number and length of each of the three different types of record in the leader file, namely, scene header, map projection ancillary and radiometric ancillary. In addition, locators are given, supplying the location and format of thirteen important data fields within the leader file.

Locators for the leader file are made up in the following way from sixteen bytes:
6 bytes - the sequence number of the record containing the field;
6 bytes - the byte number of the first byte of the field;
3 bytes - the length of the field (in bytes);
1 byte - a code for the type of data in the field.
The codes are:
A = alphanumeric in ASCII (or EBCDIC)
N = numeric in ASCII (or EBCDIC)
B = binary.

2.7.1.2 SCENE HEADER RECORD

The scene header record used by ESA conforms precisely to the recommendations of the LTWG and contains five sets of information. The first four are contained in that area of the record defined explicitly by the LTWG and the fifth occupies the area allocated for local use.

The first set defines the quadrant which is contained within the logical volume, and the full scene of which the quadrant forms a part, the second relates to fixed information about the mission, the third defines the sensor parameters and the fourth indicates the processing options. The fifth tabulates constant geometric parameters for the sensor, namely, the mirror velocity profile coefficients for the forward and reverse sweeps, the nature of any detector substitutions for missing data, the smoothing technique used on data from detectors whose signal-to-noise response was judged to be outside specifications, and the detector adjustments applied for layout geometry and multiplexer sampling delays.

2.7.1.3 ANCILLARY RECORDS

There are two types of ancillary record, namely map projection and radiometric ancillary records.

2.7.1.3.1 MAP PROJECTION ANCILLARY RECORD

The map projection ancillary record provides information about the geometric characteristics of the input (raw) and processed imagery data.

2.7.1.3.2 RADIOMETRIC ANCILLARY RECORD

The radiometric ancillary records contain the radiometric transformation tables used in converting the raw (8 bit) data to the 8 bit form as stored on this tape. In addition, the records contain the information required to convert linear digital data to the scene radiance in watts/m2sr. If different radiometric transformation tables are required for the forward and reverse scans, two records per band will be provided, where the first relates to the forward scan and the second relates to the reverse scan.

2.7.2 IMAGERY FILE

The construction of the imagery file and of its constituent records has been defined in detail by the LTWG, and the ESA implementation conforms precisely to the LTWG definition. (Those fields which have been allocated by the LTWG as for local use are clearly identified as such in the appropriate record definition).

ESA quadrant allocations follow precisely the recommendations of the LTWG, with the nominal WRS scene centre being positioned in the last pixel of the last scan line of quadrant 1. ESA has chosen to supply a fixed overlap of lines and pixels for each quadrant and the amounts of these overlaps are recorded as constant values in the scene header record of the leader file. These fields defining overlap are referenced for easy accessibility by locators in the leader file descriptor variable segment. (This information is not supplied within the imagery file itself since it specifies the relationship between this TM product and other TM products, rather than to the construction of the imagery file itself).

The imagery file contains data records, each of which contains not only the image data, but also support data such as scan line identification and quality codes. This support data is physically separated into the prefix data (which precede the image data pixels), and suffix data (which follow the image data pixels).

The organization of the imagery file may be Band Sequential (BSQ), where the file contains image data for one spectral band only, or Band Interleaved by Line (BIL), where the file contains image data for one or more spectral bands. The imagery file contains one file descriptor record, and image records containing full or half scan lines and sensor-related support data.

All imagery file data records contain the standard twelve bytes of record introductory data (namely, record number, record type and sub-types, and record length). All imagery data file records are of a fixed length (of 3600 bytes for quadrant products or of 7020 bytes of the full scan line products . In addition, all image data records are recorded in binary only. Any binary fields occupying more than one byte are stored with the bytes in descending order of significance with the most significant being stored first on the tape.

2.7.2.1 IMAGERY FILE DESCRIPTOR VARIABLE SEGMENT

The imagery file variable segment gives the number and length of the image records. In addition, locators are given, supplying the format, and location within the prefix or suffix area, of nine important data fields.

Locators for the imagery file are constructed from 8 bytes in the following way:

4 bytes - the byte number, within the prefix or suffix, of the first byte of the field;
2 bytes - length of the field in bytes;
1 byte - a letter indicating that the information is stored in the prefix (P) or suffix (S);
1 byte - a code for the type of data in the field.
The codes are:
A = alphanumeric in ASCII (or EBCDIC)
N = numeric in ASCII (or EBCDIC)
B = binary.

The remainder of the variable segment contains detailed information on how the image pixels are packed within groups of bytes, the range and justification of individual pixels, the size (if any) of left, right, top and bottom borders, the size of the prefix and suffix data, and finally the nature of the packing of multispectral lines.

For ESA Landsat TM data, each image pixel is ALWAYS stored as one 8-bit byte, and each portion of the scan line, as defined in the product definition, for each detector occupies one complete physical record.

2.7.2.2 IMAGE RECORD

The definition of the image record, as recommended by the LTWG, is reproduced here in detail, such that the user has an understanding of the relationship between products supplied by ESA and those supplied by other agencies. The rest of this document addresses in detail ESA products corrected ONLY up to level 5.

Each image record contains the following groups of data:

1. The twelve bytes of standard record introductory data (i.e. record number, record type and sub-types, and record length)

2. Twenty bytes of prefix data

3. EITHER
3500 bytes of image data corrected at a level up to and including level 5. It consists of all of the image data of one half scan line of one detector, and includes left fill and right fill pixels, and overlap pixels, as defined for the quadrant product.

OR
6920 bytes of image data corrected at a level up to and including level 5. It consists of all the image data of one scan line of one detector, and includes left fill and right fill pixels.

OR
4220 bytes of image data, corrected at levels 5, 6 or 7, projected onto the Space Oblique Mercator (SOM) (or other) grid. It consists of all the image data for one quadrant of one detector, where the quadrants are defined in relation to the WRS scene centre, and includes left fill and right fill pixels, and overlap pixels, as defined for the quadrant product. (The image data area requirements for this type of product are large since the quadrants are located EXACTLY about the WRS scene centre, the location of which may vary considerably in the original raw scene).

4.Sixty eight bytes of suffix data.

Most of the prefix data and suffix data are located by the file descriptor record variable segment for the imagery file. It should be noted that the location of such data is IDENTICAL to that for ESA MSS data. In order to achieve nominal geometric registration between adjacent scan lines from different detectors from various spectral bands, the detector adjustments shown in Table 3.3.2.3 (and also recorded in the header record of the leader file) have been made to compensate for layout geometry and multiplexer sampling delays. (A flag to indicate this correction is available in the header record of the leader file).

2.7.3 TRAILER FILE

The construction of the trailer file and of its constituent records has been defined in detail by the LTWG, and the ESA implementation conforms precisely to the LTWG definition. (Those fields which have been allocated by the LTWG as for local use are clearly identified as such in the appropriate record definition).

Trailer files follow image data files, supplying information associated with the image data which could not always be ascertained before writing the image data. This includes data quality, recording quality and data summaries. One trailer file is associated with each imagery file. Hence, for BSQ structures, which contain one imagery file for each band, there is one trailer file for each band. For BIL structures, which contain one imagery file accommodating more than one spectral band, there is only one trailer file.

Each trailer file contains the following records:

File descriptor record;
Trailer records containing trailer data for all bands of imagery in the associated imagery file.

All trailer file records contain the standard twelve bytes of record introductory data stored in binary (namely, record number, record type and sub-types, and record length). All trailer file records are of a fixed length of 4320 bytes. All data fields are stored either as alphanumeric or numeric strings recorded in ASCII, or as 32-bit binary values. Any binary fields occupying more than one byte are stored with the bytes in descending order of significance with the most significant being stored first on the tape.

2.7.3.1 TRAILER FILE DESCRIPTOR VARIABLE SEGMENT

The trailer file variable segment gives the number and length of trailer records. In addition, locators are given, supplying the location and format of two important data fields.

Locators for the trailer file are constructed, in an identical manner to those for the leader file, from 16 bytes in the following way:

6 bytes - the record number of the record containing the field;
6 bytes - the byte number of the first byte of the field;
3 bytes - the length of the field (in bytes);
1 byte - a code for the type of data in the field.
The codes are:
A = alphanumeric in ASCII (or EBCDIC)
N = numeric in ASCII (or EBCDIC)
B = binary.

2.7.3.2 TRAILER RECORD

There are two sets of four trailer records for each of the bands accommodated in the related image data file, where the first set relates to the forward mirror sweep and the second set corresponds to the reverse mirror sweep. Trailer records contain the parity error count and a quality summary, stored in ASCII. In addition, each trailer record contains the histogram of the raw data for four detectors, where each histogram entry is stored as a 32-bit binary number.

2.8 SUPPLEMENTAL LOGICAL VOLUME OVERVIEW

The only file class used in the ESA TM Supplemental logical volume is SUPPLEMENTAL FILE, with the corresponding four-character class code, SUPP. The following sub-sections describe the file descriptor record variable segment and the constituent record types.

2.8.1 SUPPLEMENTAL FILE

The LTWG has not defined in detail the construction of the supplemental file, since the contents of the file depend heavily on individual station processing techniques. However, the variable segment of the file descriptor record for the supplemental file has been designed by the LTWG and is used by ESA.

Supplemental files, as used by ESA, contain the following records:

File descriptor record;
Interval header record;
TM housekeeping data record;
Ephemeris and attitude data record;
Raw jitter measurements data record;
Mission telemetry data record.

All supplemental file records contain the standard twelve bytes of record introductory data, stored in binary, (namely, record sequence number, record type and sub-types, and record length). All the data records are supplied to cover a user-specified time interval, which may be considered as any integral number of Payload Correction Data (PCD) major frames, or of Telemetry major frames. As explained in Section 2.3.1, the counts of records in the supplemental logical volume and in the imagery logical volume are independent of each other. (However, the data within one logical volume may be correlated with the data in the other logical volume by using the time code information supplied in each).

2.8.1.1 SUPPLEMENTAL FILE DESCRIPTOR RECORD VARIABLE SEGMENT

The supplemental file variable segment gives the number and length of each of the twelve different types of record in the supplemental file. In addition, locators are given, supplying the location and format of two important data fields within the supplemental file.

Locators for the supplemental file are constructed from sixteen bytes in the following way:

6 bytes - the sequence number of the record containing the field;
6 bytes - the byte number of the first byte of the field;
3 bytes - the length of the field (in bytes);
1 byte - a code for the type of data in the field.
The codes are:
A = alphanumeric in ASCII (or EBCDIC)
N = numeric in ASCII (or EBCDIC)
B = binary.

2.8.1.2 INTERVAL HEADER RECORD

The interval header record defines the start and stop times of the PCD data supplied within the supplemental logical volume.

2.8.1.3 TM HOUSEKEEPING DATA ANCILLARY RECORD

Each TM housekeeping data record contains all the information required to interpret thirty two elements from the TM housekeeping telemetry data, as supplied in the PCD. In addition, the expanded content of five serial words is also supplied. Since there is only one block of TM housekeeping telemetry data in a set of four PCD major frames, there will be only one TM housekeeping data record for every 16.384 seconds of imagery data. Since one scene of TM video data occupies approximately 25 secs, either two or three TM housekeeping data ancillary records are required to span the full scene.

2.8.1.4 EPHEMERIS AND ATTITUDE ANCILLARY RECORD

Each ephemeris and attitude ancillary record contains all the ephemeris data, attitude data, gyro data and gyro drift data from one major frame of PCD, which spans a time period of 4.096 secs. At least six ephemeris and attitude data ancillary records are required to span one full scene of TM video data, which occupies approximately 25 secs. (The gyro data comes from the attitude control inertial reference units, which have been designed to measure jitter in the nominal frequency range from 0.01 to 2.0 Hz).

2.8.1.5 RAW JITTER MEASUREMENTS ANCILLARY RECORD

Each raw jitter measurements ancillary record contains all the information obtained from the three-axis Angular Displacement Sensor (ADS) from half of one major frame of PCD, where one PCD major frame occupies a time period of 4.096 secs. At least twelve raw jitter measurements ancillary records are required to span one full scene of TM video data, which occupies approximately 25 secs. (The ADS has been designed to measure the magnitude of the jitter in the nominal frequency range 2 to 125 Hz).

2.8.1.6 MISSION TELEMETRY ANCILLARY RECORD

The contents of the mission telemetry ancillary record are taken directly from one major frame of mission telemetry data. It consists of ephemeris and attitude data and several temperature measurements. It is not normally required for TM products, since identical information is available in the PCD.

2.9 CALIBRATION LOGICAL VOLUME OVERVIEW

The Calibration Logical Volume has been designed bye ESA-Earthnet to supply the calibration data acquired from the Landsat 4 and 5 satellites within the Thematic Mapper data stream. The Calibration Logical Volume is included in the standard ESA-Earthnet Thematic Mapper CCT products. The Calibration Logical Volume takes place, in the ESA-Earthnet TM CCT, after the Supplemental Logical Volume and before the Null Volume. The format of the Calibration Logical Volume follows the format of the Supplemental Logical Volume, and more in general, the format of the logical volumes of the Landsat family products, as designed by the LTWG. The Calibration Logical Volume contains two files:

the Volume Directory File
the Calibration Data File.

The only file class used in the ESA-Earthnet TM Calibration logical volume is CALIBRATION FILE, with the corresponding four-character class code CALB. The following sub-sections describe the volume directory file and the calibration file.

2.9.1 CALIBRATION FILE

The LTWG has not defined in detail the construction of the calibration file, since the contents of the file depend heavily on individual station processing techniques. However, the fixed segment of the file descriptor record for the calibration file has been designed by the LTWG and is used by ESA-Earthnet.

Calibration file, as used by ESA-Earthnet, contain the following records:

File descriptor record;
Calibration data records.

All calibration file records contain the standard twelve bytes of record introductory data, stored in binary, (namely, record sequence number, record type and sub-types, and record length). The calibration data are supplied to cover a time interval of 400 Thematic Mapper swaths, i.e. 28.584 seconds of satellite flight time. The counts of records in the calibration logical volume and in the imagery logical volume are independent of each other. (However, the data within one logical volume may be correlated with the data in the other logical volume by using the pointer supplied in the file descriptor record - variable portion).

CHAPTER 3

LANDSAT TM LOGICAL VOLUME DEFINITIONS

This chapter is devoted to the detailed file and record construction of the CCT, and is organized so that the detailed content of each record is shown in the order in which it appears on the tape. Each record is represented as a table consisting of seven fields :

- name of the field or field-group
- field-group indicator (nothing if single field, "*" if field-group)
- starting byte of this field (field-group) in this record
- last byte of this field (field-group) in this record
- format in which the data of this field is written on tape
- definition and explanation of the content of this field
- actual content of the field if it is a constant for an EPO product

The data is written on and should be read from the tape using the standard fortran format as described in the fifth field and explained below:

xBn : x times data written in binary form on n bytes (unformatted)

xIn : x times data written as integer values formatted on n digits for example 123 written as 1I4 is: " 123"

xFn.m : x times data written as real numbers on a total of n digits including dot and sign, with m digits for the decimal part 123.456 written as 1F10.4 is: " +123.4560"

xEn.m : x times data written as real numbers with exponent on a total of n digits including dot, two signs and "E", with m digits for the decimal part and two digits for the exponent
1234.567 written as 1E14.6 is: " +1.234567E+03"

xAn : x strings of n ASCII characters

3.1 IMAGERY LOGICAL VOLUME - VOLUME DIRECTORY FILE

The Volume Directory File is the first file of every Landsat TM logical volume and consists of a Volume Descriptor Record, File Pointer Records and a Text Record. According to standard format family conventions, the volume directory file is repeated, with certain fields updated, whenever a logical volume spans more than one physical volume. Those fields which are modified when the volume directory is repeated at the start of a new physical volume are identified with notes in the detailed record layout tables.

The five following tables contain the description and content of the following records :

1. VOLUME DESCRIPTOR RECORD

There are three file classes in the imagery logical volume, ad the File Pointer Records contain the names and codes of these file classes, as follows:

CLASS NAME	CLASS CODE	FILE CONTENT
LEADER FILE	LEAD	Scene header, scene-related ancillary records
IMAGERY FILE	IMGY	Image data records
TRAILER FILE	TRAI	Trailer records

2. FILE POINTER RECORD FOR LEADER FILE
3. FILE POINTER RECORD FOR IMAGERY FILE
4. FILE POINTER RECORD FOR TRAILER FILE
5. TEXT RECORD

IAGERY_VOLUME
)LUME_DIRECTORY_FILE
)LUME_DESCRIPTOR_RECORD

eld or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Sequence Number	1
2	5	5	B1	1st record sub-type code (Decimal)	192
3	6	6	B1	Record type code (Decimal)	192
4	7	7	B1	2nd record sub-type code (Decimal)	18
5	8	8	B1	3rd record sub-type code (Decimal)	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	28	A12	Superstructure control document number	CCB-CCT-0002
10	29	30	A2	Superstructure control document revision nuaber <XX> (initially '$C')	
11	31	32	A2	Superstructure record format revision letter <XX> (initially '$A',then '$B',ext...)	
12	33	44	A12	Software release number TMFR-CCT-<XXX> (initially XXX = 001,then 002,ext.)	
13	45	60	A16	identifier of logical volume containing this volume descriptor : <MNSYYDDDPPPRRRAA>	
14	61	76	A16	Physical Volume ID : <AAQYYDDDHHMMSSNN>	
15	77	92	A16	Volume Set ID	LANDSAT5TM$$$$
16	93	94	I2	Number of Physical Volumes in the Set <$N> where N=1,or2,or3.	
17	95	96	I2	Physical Volume Number, Start of Logical Volume	$1
18	97	98	I2	Physical Volume Number, End of Logical Volume <$N> where N=1,or2,or3.	
19	99	100	I2	Physical Volume seqoence number (i.e. of current tape) <$N> where N=1,or2,or3.	
20	101	104	I4	First Referenced File Number in this Physical Volume	
21	105	108	I4	Logical Volume Number within Volume Set	$$$1
22	109	112	I4	Logical Volume Number within Physical Volume	$$$1
23	113	120	A8	Logical Volume Creation Date <YYYYMMDD>	
24	121	128	A8	Logical Volume Creation Time <HHMMSSXX>	
25	129	140	A12	Logical Volume Generating Country ITA - FUCINO or SWE - KIRUNA	
26	141	148	A8	Logical Volume Generating Agency	ESA-EPO
27	149	160	A12	Logical Volume Generating Facility ITA - FUCINO or SWE - KIRUNA	
28	161	164	I4	Number of Pointer Records in Volume Directory 3 for BIL,(3*n) for BSQ where n is the number of spectral bands	
29	165	168	I4	Number of Records in Volume Directory 5 for BIL,(2+3*n) for BSQ	
30	169	260	A92	Volume Descriptor Spare Segment	Blanks
31	261	360	A100	Local Use Segment	Blanks

IMAGERY_VOLUME
VOLUME_DIRECTORY_FILE
LEADER_FILE_POINTER_RECORD

field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Sequence Number 2 for BIL, 2,5,8,11,14,17 or 20 for BSQ	
2	5	5	B1	1st record sub-type code	219
3	6	6	B1	Record type code	192
4	7	7	B1	2nd record sub-type code	18
5	8	8	B1	3rd record sub-type code	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	20	I4	Referenced File Number 1 for BIL, 1,4,7,10,13,16 or 19 for BSQ	
10	21	36	A16	Referenced File Name LS4$TM<LL>LEADBIL$ 5 BSQm This field can take as values 2*8*7 combinations e.g. LS4TM2LEADBSQ5 where m is the band number to which the associated imagery belongs, and <LL> represents the level of corrections applied.	
11	37	64	A28	Referenced File Class	LEADER$FILE
12	65	68	A4	Referenced File Class Code	LEAD
13	69	96	A28	Referenced File Data Type	MIXED$BINARY$AND$ASCII
14	97	100	A4	Referenced File Data Type Code	MBAA
15	101	108	I8	Number of Records in Referenced File 3 + n (or 3 + 2*n) where n is the number of spectral bands in the related imagery file.	
16	109	116	I8	Referenced File - Descriptor Record Length	4320
17	117	124	I8	Referenced File Maximum Record Length	4320
18	125	136	A12	Referenced File Record Length Type	FIXED$LENGTH
19	137	140	A4	Referenced File Record Length Type Code	FIXD
20	141	142	I2	Referenced File Physical Volume Number, Start of File <$N> where N=1,2 or 3	
21	143	144	I2	Referenced File Physical Volume Number, End of File <$N> where N=1,2 or 3	
22	145	152	I2	Referenced File Portion, 1st Record Number for this Physical Volume <$N> where N=1 or a number smaller than field 1	
23	153	160	I8	Referenced file portion, last record number for this physical volume 3 + n (or 3 + 2*n) where n is the number of spectral bands in the related imagery file.	
24	161	260	A100	Pointer Spare Segment	Blanks
25	261	360	A100	Local Use Segment	Blanks

MAGERY_VOLUME
OLUME_DIRECTORY_FILE
MAGERY_FILE_POINTER_RECORD

Field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Sequence Number 3 for BIL, 3,6,9,12,15,18 or 21 for BSQ	
2	5	5	B1	1st record sub-type code	219
3	6	6	B1	Record type code	192
4	7	7	B1	2nd record sub-type code	18
5	8	8	B1	3rd record sub-type code	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	20	I4	Referenced File Number 2 for BIL, 2,5,8,11,14,17 or 20 for BSQ	
10	21	36	A16	Referenced File Name LS4$TM<LL>IMGYBIL$ 5 BSQn This field can take as values 2*8*7 combinations e.g. LS4TM2IMGYBSQ5 where n is the band number to which the associated imagery belongs, and <LL> represents the level of corrections applied.	
11	37	64	A28	Referenced File Class	IMAGERY$FILE
12	65	68	A4	Referenced File Class Code	IMGY
13	69	96	A28	Referenced File Data Type	BINARY$ONLY
14	97	100	A4	Referenced File Data Type Code	BINO
15	101	108	I8	Number of Records in Referenced File n*2944 + 1 where n is the number of spectral bands in the related imagery file.	
16	109	116	I8	Referenced File - Descriptor Record Length 3600 for quarter,7020 for full frame	
17	117	124	I8	Referenced File Maximum Record Length 3600 for quarter,7020 for full frame	
18	125	136	A12	Referenced File Record Length Type	FIXED$LENGTH
19	137	140	A4	Referenced File Record Length Type Code	FIXD
20	141	142	I2	Referenced File Physical Volume Number, Start of File	$1
21	143	144	I2	Referenced File Physical Volume Number, End of File	$1
22	145	152	I2	Referenced File Portion, 1st Record Number for this Physical Volume	$1
23	153	160	I8	Referenced file portion, last record number for this physical volume n*2944 + 1 where n is the number of spectral bands in the related imagery file.	
24	161	260	A100	Pointer Spare Segment	Blanks
25	261	360	A100	Local Use Segment	Blanks

IMAGERY_VOLUME
VOLUME_DIRECTORY_FILE
TRAILER_FILE_POINTER_RECORD

field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Sequence Number 4 for BIL, 4,7,10,13,16,19 or 22 for BSQ	
2	5	5	B1	1st record sub-type code	219
3	6	6	B1	Record type code	192
4	7	7	B1	2nd record sub-type code	18
5	8	8	B1	3rd record sub-type code	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	20	I4	Referenced File Number 3 for BIL, 3,6,9,12,15,18 or 21 for BSQ	
10	21	36	A16	Referenced File Name LS4$TM<LL>TRAIBIL$ 5 BSQn This field can take as values 2*8*7 combinations e.g. LS4TM2TRAIBSQ5 where n is the band number to which the associated imagery belongs, and <LL> represents the level of corrections applied.	
11	37	64	A28	Referenced File Class	TRAILER$FILE
12	65	68	A4	Referenced File Class Code	TRAI
13	69	96	A28	Referenced File Data Type	MIXED$BINARY$AND$ASCII
14	97	100	A4	Referenced File Data Type Code	M2AA
15	101	108	I8	Number of Records in Referenced File 4*n + 1 or 2*4*n + 1 where n is the number of spectral bands in the related imagery file. There are four records for each band in the associated imagery file, plus one file descriptor record.	
16	109	116	I8	Referenced File - Descriptor Record Length	4320
17	117	124	I8	Referenced File Maximum Record Length	4320
18	125	136	A12	Referenced File Record Length Type	FIXED$LENGTH
19	137	140	A4	Referenced File Record Length Type Code	FIXD
20	141	142	I2	Referenced File Physical Volume Number, Start of File	$1
21	143	144	I2	Referenced File Physical Volume Number, End of File	$1
22	145	152	I2	Referenced File Portion, 1st Record Number for this Physical Volume	$1
23	153	160	I8	Referenced file portion, last record number for this physical volume 4*n + 1 or 2*4*n + 1 where n is the number of spectral bands in the related imagery file. There are four records for each band in the associated imagery file, plus one file descriptor record.	
24	161	260	A100	Pointer Spare Segment	Blanks
25	261	360	A100	Local Use Segment	Blanks

GERY_VOLUME
UME_DIRECTORY_FILE
T_RECORD

ld or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Number	
2	5	5	B1	1st record sub-type code	18
3	6	6	B1	record type code, always	63
4	7	7	B1	2nd record sub-type code	18
5	8	8	B1	3rd record sub-type code	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC flag for this record	A$
8	15	16	A2	Continuation flag. This field contains two blanks unless the information of this record is continued on a following record, in which case, the field is coded C$.	
9	17	66	A50	Product id <SSS>$<LSNQPPPRRRYYDDDCC>, where SSS = Sensor Type ($TM) LSN = Landsat Mission (N=4 or 5) Q = Quadrant Number (1,2,3,4 or F if full scene) PPP = Path Number RRR = Row Number YY = Last 2 digits of year (01-99) DDD = Day of year (001-366) CC = Correction Applied (0-11).See Table 2.1	
10	67	124	A58	Location and date/time of product creation	
11	125	136	A12	Scene identification <MDDDDDHHMMSS>, where M = Mission Number 4 for Landsat-D 5 for Landsat-D' DDDDD = Days since launch at time of observation HH = GMT hour at time of observation MM = GMT minute at time of observation SS = GMT seconds at time of observation	
12	137	140	A4	quadrant number of scene <X>, where X=1,2,3,4 or F if full scene	
13	141	144	A4	Interleaving type $BIL or $BSQ	
14	145	156	A12	Blanks	
15	157	172	A16	Tape reel id (See Table 3.1.1.1.,field 14 for explanation)	
16	173	176	A4	Blanks	
17	177	180	A4	HDDR Identification	
18	181	196	A16	Spare	
19	197	202	A6	Date of HDT generation <YYDDD>$	
20	203	360	A158	Blanks	

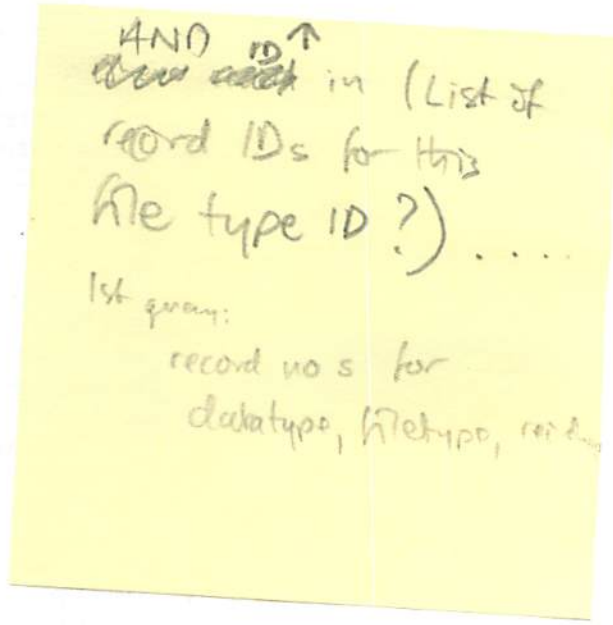
3.2 IMAGERY LOGICAL VOLUME - LEADER FILE

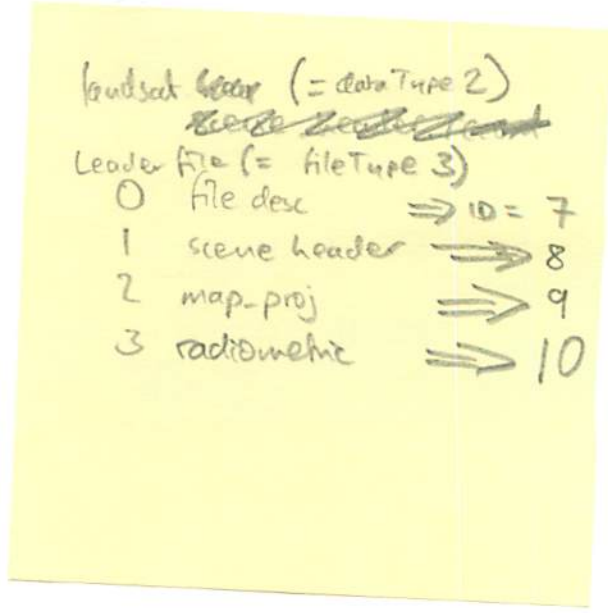
The Leader file is the first data file in the imagery logical volume, and is of the class LEADER FILE with the class code LEAD.

The following four tables contain the description and content of the folllowing records :

1. FILE DESCRIPTOR RECORD
2. SCENE HEADER RECORD
3. MAP PROJECTION ANCILLARY RECORD
4. RADIOMETRIC ANCILLARY RECORD

Since full scan lines of band 6 (thermal) data are replicated four times, to achieve the same pixel centre to pixel centre spacing for all bands, the transformation tables for each of the band 6 detectors are replicated six times.





MAGERY_VOLUME
EADER_FILE
ILE_DESCRIPTOR_RECORD

ield or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
FDR_FIXED_SEGM *	1	180		FILE DESCRIPTOR RECORD FIXED SEGMENT	
1	1	4	B4	Record Sequence Number	1
2	5	5	B1	1st record sub-type code (DECIMAL)	63
3	6	6	B1	Record type code (DECIMAL)	192
4	7	7	B1	2nd record sub-type code (DECIMAL)	18
5	8	8	B1	3rd record sub-type code (DECIMAL)	18
6	9	12	B4	Length of this record	4320
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	28	A12	Control Document Number for this Data File Format	Always GES$10490$$$
10	29	30	A2	Control Document Revision Number <NN>,where NN=01-99	
11	31	32	A2	File Design Descriptor Revision Letter <XX>, (Initially '$A',then '$B',etc.)	
12	33	44	A12	Software Release Number TMFR-CCT-<XXX>, initiall XXX=001,then 002,etc	
13	45	48	I4	File Number 1 for BIL; 1,4,7,10,13,16 or 19 for BSQ	
14	49	64	A16	File Name . LS5$TM<LL>LEADBSQm or LS5$TM<LL>LEADBIL$ This field can take as value 2*8*7 combinations e.g. LS4TM2LEADBSQ6,where m is the band number to which the associated imagery relates,and <LL> is the level of corrections applied.	
15	65	68	A4	Record Sequence and Location Type Flag	FSEQ
16	69	76	I8	Sequence Number Location	$$$$$$$1
17	77	80	I4	Sequence Number Field Length	$$$4
18	81	84	A4	Record Code and Location Type Flag	FTYP
19	85	92	I8	Record Code Location	$$$$$$$5
20	93	96	I4	Record Code Field Length	$$$4
21	97	100	A4	Record Length and Location Type Flag	FLGT
22	101	108	I8	Record Length Location	$$$$$$$9
23	109	112	I4	Record Length Field Length	$$$4
24	113	113	A1	Flag indicating that data interpretation information is included within the file descriptor record. <X> ,where X=Y OR N ,for YES or NO	
25	114	114	A1	Flag indicating that data interpretation information is included within the file in record(s) other than the descriptor <X> ,where X=Y OR N ,for YES or NO	
26	115	115	A1	Flag indicating that data display information is included within the file descriptor record. <X> ,where X=Y OR N ,for YES or NO	
27	116	116	A1	Flag indicating that data display information is included within the file in record(s) other than the file descriptor. <X> ,where X=Y OR N ,for YES or NO	

28		117	180		Reserved Segment	Blanks
FDR_VARIA_SEGM	*	181	4320		FILE DESCRIPTOR RECORD VARIABLE SEGMENT	
29		181	186	I6	Number of scene records	$$$$$1
30		187	192	I6	Header record length	$$4320
31		193	198	I6	Number of map projection ancillary records	$$$$$1
32		199	204	I6	Ancillary record length	$$4320
33		205	210	I6	Number of radiometric calibration ancillary records N is the number of spectral bands in the related imagery file. $$$$$N (where N = 1,...,7)	
34		211	216	I6	Length of above record	$$4320
LOC_FIELDS	*	217	424		LOCATOR FIELDS The locator fields point to the position in the file where various information can be found. The locator information is coded in 16 bytes ASCII : Bytes 1- 6 = record number containing that field Bytes 7-12 = byte position of the field within the rec Bytes 13-15 = length of field in bytes Byte 16 = type of data code A for alphanumeric; B for binary; N for numeric;	
35		217	232	A16	Scene identification field locator	$$$$$2$$$$37$16A
36		233	248	A16	WRS identification field locator	$$$$$2$$$165$16A
37		249	264	A16	Mission identification field locator	$$$$$2$$$309$16A
38		265	280	A16	Sensor identification field locator	$$$$$2$$$325$16A
39		281	296	A16	Scene center date-time locator	$$$$$2$$$117$32A
40		297	312	A16	Geographic reference field locator	$$$$$2$$$213$32B
41		313	328	A16	Image processing performed field locator	$$$$$2$$1573$16A
42		329	344	A16	Imagery format field locator	$$$$$2$$1717$16A
43		345	360	A16	Band indicator locator	$$$$$2$$1653$64N
44		361	376	A16	Subscene indicator locator	$$$$$2$$$$27$01A
45		377	392	A16	Pixel size field locator	$$$$$3$$$365$32N
46		393	408	A16	Quadrant vertical overlap locator	$$$$$2$$$277$16N
47		409	424	A16	Quadrant horizontal overlap locator	$$$$$2$$$293$16N
48		425	4320	A74	Blanks	

IMAGERY_VOLUME
LEADER_FILE
SCENE_HEADER_RECORD

Field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Sequence Number	
2	5	5	B1	1st record sub-type code	18
3	6	6	B1	Record type code	18
4	7	7	B1	2nd record sub-type code	
5	8	8	B1	3rd record sub-type code	9
6	9	12	B4	Length of this record	4320
7	13	16	I4	Header record sequence number	1
8	17	20	A4	Blanks	$$$$
				NOTE From field 9. all fields in the Header Record are multiples of 4 bytes long, and are in either Numeric or Alphanumeric format. All Numeric fields are right-justified and the default format is F16.7 unless otherwise specified. All Alphanumeric fields are left-justified. All references to the input scene refer to the WRS scene.All references to the processed scene refer to the quadrant or to the full scene. Fields not listed do not require additional explanation. Latitude is measured positive to the north, negative to the south. Longitude is measured positive to the east, negative to the west.	
SCE_PAR *	21	308		SCENE PARAMETERS	
9	21	36	A16	Product identification Product identification defined as : <SSS>$<LSNQPPPRRRYYDDDCC>, where SSS = Sensor Type ($TM) LSN = Landsat Mission (N=4 or 5) Q = Quadrant Number (1,2,3,4 or F if full scene) PPP = Path Number RRR = Row Number YY = Last 2 digits of year (01-99) DDD = Day of year (001-366) CC = Correction Applied (0-11)	
10	37	52	A16	Input scene identification <LDDDDHHMM>$$$$$$$, where: L=Mission number DDDD=Day number since launch HHMMSS=Hours and minutes GMT at which the centre point was imaged.	
11	53	68	F16.7	Input scene (frame) centre latitude in degrees	
12	69	84	F16.7	Input scene (frame) centre longitude in degrees	
13	85	100	F16.7	Line number at input scene centre	
14	101	116	F16.7	Pixel number at input scene centre	
15	117	148	A32	Input scene centre time <YYYYMMDDHHMMSS>, followed by 18 blanks, where YYYY=year MM=month	

				DD=day HH=hours (00 to 23) MM=minutes (00 to 59) SS=minutes (00 to 59)
16	149	164	I16	Time offset from WRS frame (msecs) Time offset in milliseconds from standard framing corresponding to the Worldwide Reference System
17	165	180	A16	WRS designator (path and row) <MPPPRRR>$, followed by 8 blanks, where: M=A (for ascending node) or M=D (for descending node) PPP=WRS nominal path number (001-233) RRR=WRS nominal row number (001-248)
18	181	196	I16	WRS cycle. Number of orbital cycles since launch
19	197	212	A16	Processed scene (frame/quadrant) identification It consists of the input scene identifier followed by a one byte quadrant identifier, <LDDDDHHMMSSX>$$$$, where: L=Mission number DDDD=Day number since launch HHMMSS=Hours, minutes and seconds GMT at which the centre point was imaged X=Quadrant number, where quadrant 1 contains the upper left quarter, quadrant 2 contains the upper right quarter, quadrant 3 the lower left quarter, and quadrant 4 contains the lower right quarter of the full scene.
20	213	228	F16.7	Processed scene centre (frame/quadrant) latitude in degrees.
21	229	244	F16.7	Processed scene (frame/quadrant) centre longitude in degrees
22	245	260	F16.7	Line number at processed scene (frame/quadrant) center.
23	261	276	F16.7	Pixel number at processed scene (frame/quadrant) center. This is the pixel number which is designated as the processed scene centre. For system corrected products, any line length changes made for panoramic distorsion and earth curvature curvature effects are included. This number is relative to the image portion of record, i.e. do not include prefix and left fillers.
24	277	292	I16	Count of overlap lines This is the number, L, of overlap lines, counted in one direction only, defined as being the number of lines wich belong to the quadrant immediately above (or below) the current quadrant. In case of full frame this number is set to 0.
25	293	308	I16	Count of overlap pixels This is the number, P, of overlap pixels, counted in one direction only, defined as being the number of pixels wich belong to the adjacent quadrant. In case of full frame this number is set to 0.
MIS_PAR *	309	372		' MISSION PARAMETERS
26	309	324	A16	Mission identification LANDSAT-4, LANDSAT-5, followed by 7 blanks,

					for Landsat D and D prime respectively.	
27		325	340	A16	Sensor identification It will be TM, followed by 14 blanks, for the Thematic Mapper	
28		341	356	I16	Orbit number	
29		357	372	A16	Ascending/descending flag Set to A for ascending paths and to D for descending paths.	
SEN_PAR	*	373	1476		SENSOR PARAMETERS	
30		373	388	A16	Spare	
31		389	1412	A1024	Local use	Blanks
32		1413	1428	I16	Number of active bands in the processed image The total number of active bands is n. All subsequent reference to band number is by 'logical band number' where each of the active bands, in ascending order, is assigned a logical band number in the range 1 to n.	
33		1429	1444	I16	Number of scene pixels per line in the processed image This is the actual number of scene pixels per line in the imagery file following this Leader file. It is recalculated for system corrected products to allow for panoramic distorsion correction, earth curvature correction, mirror velocity profile and line length corrections.	
34		1445	1460	I16	Number of scene lines in the processed image This is the actual number of scene lines in the imagery file following this Leader file.	
35		1461	1476	A16	Spare	
PRO_PAR	*	1477	2680		PROCESSING PARAMETERS	
					Each processing option designator may be considered as a string of 16 1-byte codes, each specifying whether the identified correction has been applied (value = 'Y') or has not been applied (value = 'N').	
36		1477	1492	16A1	Radiometric calibration designator Radiometric (sensor) calibration (sixteen bytes) BYTE OPTION 1 Internal calibration source 2 Pre-flight data 3 Histogram equalization 4 Sun elevation correction 5 Film gamma correction 6 Scenic correction 7 Histogram mean and standard deviation Bytes 1 thru 7 are coded Y/N (for Yes or Not). Bytes 10 thru 16 may be used by other agencies to store one radiometric processing code for each of the seven bands.	
37		1493	1508	I16	Radiometric resolution designator The number of bits required to store the maximum data range will always been 8. This value is right justified in the field.	
38		1509	1524	16A1	Scenic radiometric correction designator	

				BYTE OPTION 1 Completely raw data 2 Linear representation 3 Logarithmic representation 4 Other non-linear representation 5 Reserved (set to 'N') 6 Sun illumination angle correction 7 Haze correction 8 Sun illumination angle and haze correction 9 Standard radiometric enhancement 10 Rangeland enhancement 11 Forestry enhancement 12 Custom enhancement
39		1525	1540	16A1	Geometric correction designator BYTE OPTION 1 Forward/reverse alignment 2 Detector placement and delay 3 Mirror scan profile 4 Line length information 5 Gyro data 6 Angular displacement sensor (ADS) data 7 Attitude correction system (ACS) data 8 Ephemeris data 9 Scan gap 10 Ground control points 11 Earth rotation 12 Sensor altitude and panoramic distortion 13 Digital terrain model (DTM) 14 PCD availble or not
40		1541	1556	16A1	Resampling algorithm designator BYTE OPTION 1 No resampling 2 Resampling along line only 3 Two-dimension resampling Bytes 4 thru 12 take the value 'N'. The last 4 bytes take one of the following codes: NONE - None (always applicable to raw products) NN$$ - Nearest neighbour (usually applicable to bulk corrected products) CC$$ - Cubic convolution S8$$ - 8-point (sin x)/x DS8$ - 8-point damped (sin x)/x S16$ - 16-point (sin x)/x DS16 - 16-point damped (sin x)/x BLI$ - bilinear interpolation PSD$ - pixel stuff/delete
41		1557	1572	16A1	Map projection identifier BYTE OPTION 1 No projection 2 UTM/Polar stereogaphic 3 SOM (Space Oblique Mercator) 4 Geocoded product
42		1573	1588	A16	Product processing level The product class is stored in bytes 1573 and 1574 as two numeric characters representing the overall level of corrections applied, as shown in Table Table 2.1 and Table 2.2.

43	1589	1604	I16	Number of Map Projection ancillary records	
44	1605	1620	A16	Spare	
45	1621	1636	A16	Spare	
46	1637	1652	I16	Number of Radiometric ancillary records	
47	1653	1716	64A1	Active bands One byte per band, maximum of 64 bands where the n'th byte is set to 1 if the band is active, and to 0 otherwise.	
48	1717	1732	A16	Interleaving indicator BIL$$$$$$$$$$$$$ or BSQ$$$$$$$$$$$$$ for Band Interleaved by Line or Band Sequential	
				NOTE The detector numbering convention is as follows: DETECTOR — BAND, DETECTOR 1 thru 16 — 1, detectors 1 thru 16 17 thru 32 — 2, detectors 1 thru 16 33 thru 48 — 3, detectors 1 thru 16 49 thru 64 — 4, detectors 1 thru 16 65 thru 80 — 5, detectors 1 thru 16 81 thru 84 — 6, detectors 1 thru 4 85 thru 100 — 7, detectors 1 thru 16	
49	1733	2132	100I4	Detector substitution array This field may be considered as an array of size 100 4-bytes ASCII elements in I4 format, one element for each of the 100 Tm detectors. The n'th element contains the detector number, m, which actually recorded the imagery data which is supplied for detector n.	
50	2133	2232	100A1	Detector smoothing array This field may be considered as an array of size 100 1-byte ASCII element, one element for each of the 100 Tm detectors. A1-byte ASCII code is used to signify the smoothing technique used. A blank code indicates no smoothing has been applied.	
51	2233	2424	A192	Local use	Blanks
52	2425	2680	A256	Local use	Blanks
53	2681	4320	A1640	Spare	Blanks

IMAGERY_VOLUME
LEADER_FILE
MAP_PROJECTION_ANCILLARY_RECORD

field or field-group name		start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1		1	4	B4	Record sequence number	
2		5	5	B1	1st record sub-type code	36
3		6	6	B1	Record type code	36
4		7	7	B1	2nd record sub-type code	18
5		8	8	B1	3rd record sub-type code	9
6		9	12	B4	Record length	4320
MAP_PRO_DAT	*	13	92		MAP PROJECTION DATA NOTE: all references to the input scene refer to the full WRS frame, whereas all references to the processed scene refer to the quadrant or to the full scene.	
7		13	28	I16	Input line nominal number of scene pixel	
8		29	44	I16	Input image nominal number of scene lines	
9		45	60	F16.7	Nominal scale of input inter-pixel distance in metres at nadir	
10		61	76	F16.7	Nominal scale of input inter-line distance in metres at nadir	
11		77	92	F16.7	Image skew at scene centre	
	*	93	332		UTM/PS RELATED DATA	
12		93	108	A16	UTM datum and zone number for input image where UTM datum = 'NAD83' or 'NAD27'	
13		109	124	F16.7	Nominal WRS northing of centre in metres	
14		125	140	F16.7	Nominal WRS easting of centre in metres	
15		141	156	F16.7	Northing of input image centre in metres	
16		157	172	F16.7	Easting of input image centre in metres	
17		173	188	F16.7	Vertical offset of scene centre to WRS nominal centre	
18		189	204	F16.7	Horizontal offset of scene centre to WRS nominal centre	
19		205	220	F16.7	Orientation of input image centre in degrees (angle of projection axis from true north)	
20		221	332	A12	Blanks.(reserved for SOM related data)	
	*	333	4320		PROCESSED SCENE RELATED DATA	
21		333	348	I16	Number of pixels per line of processed image	
22		349	364	I16	Number of lines per processed image	
23		365	380		Scale of processed inter-pixel distance in metres	
24		381	396	F16.7	Scale of processed inter-line distance in metres	
25		397	412	I16	UTM zone number for processed image	
26		413	428	F16.7	Line number in processed image at WRS scene centre	
27		429	444	F16.7	Pixel number in processed scene at WRS scene centre	

28	445	460	F16.7	Orientation of processed image centre in degrees (angle of projection axis from true North)
29	461	476	F16.7	Nominal satellite orbital inclination
30	477	492	F16.7	Nominal ascending node (longitude at equator)
31	493	508	F16.7	Nominal altitude in metres
32	509	524	F16.7	Nominal ground speed in metres per second
33	525	540	F16.7	Satellite heading in degrees (real subsatellite track direction angle, including earth rotation at the centre of the image)
34	541	556	A16	Spare (zero-fill)
35	557	572	F16.7	Cross-track field of view in degrees
36	573	588	F16.7	Sensor scan rate in scans per second
37	589	604	F16.7	Sensor active sampling rate in samples per second
38	605	620	F16.7	Sun elevation angle at WRS centre in degrees Local use
39	621	636	F16.7	Sun azimuth angle at WRS centre in degrees Local use
40	637	4320	A3684	Zero fill (Local use)

IMAGERY VOLUME
LEADER FILE
RADIOMETRIC_ANCILLARY_RECORD

field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record sequence number	
2	5	5	B1	1st record sub-type code	63
3	6	6	B1	Record type code	36
4	7	7	B1	2nd record sub-type code	18
5	8	8	B1	3rd record sub-type code	9
6	9	12	B4	Record length	4320
7	13	16	I4	Band number = 1 to 7	
8	17	20	I4	Lower reflectance limit (percentage) used in the contrast stretch range from 0 to 100	
9	21	24	I4	Upper reflectance limit (percentage) used in the contrast stretch range from 0 to 100	
10	25	28	I4	Equalizing reference detector In the radiometric calibration process, one detector in each band is defined as the equalizing reference detector, for which an absolute calibration is computed. The other detectors are matched to it using histogram analysis, to reduce the effects of radiometric striping. If this technique is not used it is set to 0.	
11	29	48	E20.10	Offset coefficient (A0)	
12	49	68	E20.10	Gain coefficient (A1) The A0 and A1 coefficient may be used in conjunction with the expression R' = A0 + V'*A1 to convert linear digital values , V', in the current band to scene radiance, R' (in watts /m2sr). Each coefficient is stored in 20 bytes corresponding to the FORTRAN format E20.10. NOTE : Fields 13 to 28 each contain 256 data items for one of the 16 detectors within the band where each data item can take a value between 0 and 255, and is stored as a binary value in 1 byte. Since full scan lines of band 6 data are replicated four times, the transformation tables for each of the four band 6 detectors are replicated four times. If the transformation tables are changed within the product, fields 13 thru 28 will be zero-filled. The gains and offsets used to generate the transformation tables, on a line by line basis, can be extracted from the suffix area of the image data record.	
13	69	324	256B1	Detector 1 lookup table	
14	325	580	256B1	Detector 2 lookup table	
15	581	836	256B1	Detector 3 lookup table	

16	837	1092	256B1	Detector 4 lookup table
17	1093	1348	256B1	Detector 5 lookup table
18	1349	1604	256B1	Detector 6 lookup table
19	1605	1860	256B1	Detector 7 lookup table
20	1861	2116	256B1	Detector 8 lookup table
21	2117	2372	256B1	Detector 9 lookup table
22	2373	2628	256B1	Detector 10 lookup table
23	2629	2884	256B1	Detector 11 lookup table
24	2885	3140	256B1	Detector 12 lookup table
25	3141	3396	256B1	Detector 13 lookup table
26	3397	3662	256B1	Detector 14 lookup table
27	3663	3908	256B1	Detector 15 lookup table
28	3909	4164	256B1	Detector 16 lookup table
29	4165	4320	A4156	Spare (local use)

3.3 IMAGERY LOGICAL VOLUME - IMAGERY FILE

In the BSQ organisation, there is one imagery file containing all 2944 scan lines of imagery data for one spectral band. In the BIL organisation, there is one imagery file containing all 2944 scan lines of imagery data for ALL of the requested spectral bands. The imagery file is of class IMAGERY FILE, with the class code IMGY. The imagery file contains the following records whose description and content are contained in the following tables :

1. FILE DESCRIPTOR RECORD
2. IMAGE RECORD for quarter scene
3. IMAGE RECORD for full frame scene

MAGERY_VOLUME
MAGERY_FILE
ILE_DESCRIPTOR_RECORD

ield or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
FDR_FIXED_SEGM *	1	180		FILE DESCRIPTOR RECORD FIXED SEGMENT	
1	1	4	B4	Record Sequence Number	1
2	5	5	B1	1st record sub-type code (DECIMAL)	63
3	6	6	B1	Record type code (DECIMAL)	192
4	7	7	B1	2nd record sub-type code (DECIMAL)	18
5	8	8	B1	3rd record sub-type code (DECIMAL)	18
6	9	12	B4	Length of this record 3600 for quarter,7020 for full frame	
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	28	A12	Control Document Number for this Data File Format	GDS$1049O$$$
10	29	30	A2	Control Document Revision Number <NN>,where NN=01-99	
11	31	32	A2	File Design Descriptor Revision Letter <XX>, (Initially '$A',then '$B',etc.)	
12	33	44	A12	Software Release Number TMFR-CCT-<XXX>, initiall XXX=001,then 002,etc	
13	45	48	I4	File Number 2 for BIL; 2,5,8,11,14,17 or 20 for BSQ	
14	49	64	A16	File Name LS5$TM<LL>IMGYBSQn or LS5$TM<LL>IMGYBIL$ This field can take as value 2*8*7 combinations e.g. LS4TM2IMGYBSQ6,where n is the band number to which the associated imagery relates,and <LL> is the level of corrections applied.	
15	65	68	A4	Record Sequence and Location Type Flag	FSEQ
16	69	76	I8	Sequence Number Location	$$$$$$$1
17	77	80	I4	Sequence Number Field Length	$$$4
18	81	84	A4	Record Code and Location Type Flag	FTYP
19	85	92	I8	Record Code Location	$$$$$$$5
20	93	96	I4	Record Code Field Length	$$$4
21	97	100	A4	Record Length and Location Type Flag	FLGT
22	101	108	I8	Record Length Location	$$$$$$$9
23	109	112	I4	Record Length Field Length	$$$4
24	113	113	A1	Flag indicating that data interpretation information is included within the file descriptor record. <X> ,where X=Y OR N ,for YES or NO	
25	114	114	A1	Flag indicating that data interpretation information is included within the file in record(s) other than the descriptor <X> ,where X=Y OR N ,for YES or NO	
26	115	115	A1	Flag indicating that data display information is included within the file descriptor record. <X> ,where X=Y OR N ,for YES or NO	
27	116	116	A1	Flag indicating that data display information is included within the file in record(s) other than the file descriptor.	

					<X> ,where X=Y OR N ,for YES or NO	
28		117	180		Reserved Segment	Blanks
FDR_VARIA_SEGM	*	181	4320		FILE DESCRIPTOR RECORD VARIABLE SEGMENT	
29		181	186	I6	Number of image records <NNNN> for BSQ,<n*NNNN> for BIL with in this file NNNN the number of scan lines including overlap and n the number of spectral bands in the product.	
30		187	192	I6	Image records length 3600 for quarter,7020 for full frame	
31		193	216	A24	Reserved	Blanks
	*	217	232		PIXEL GROUP DATA	
32		217	220	I4	Number of bits per pixel	$$$8
33		221	224	I4	Number of pixels per data group	$$$1
34		225	228	I4	Number of bytes per data group	$$$1
35		229	232	A4	Justification and order of pixels within data grou	RJLR
	*	233	272		IMAGE DATA	
36		233	236	I4	Number of bands of imagery in this file $$$n for BIL and $$$1 for BSQ	
37		237	244	I8	Number of lines per image(one band) excluding top and bottom border lines.<$$$$NNNN> like field 1.	
38		245	248	I4	Number of left border pixels	$$$0
39		249	256	I8	Number of image pixels per line 3500 for quarter,6920 for full frame	
40		257	260	I4	Number of right border pixels	$$$0
41		261	264	I4	Number of top border lines	$$$0
42		265	268	I4	Number of bottom border lines	$$$0
43		269	272	A4	Interleaving indicator $BSQ for Band Sequential or BIL for Band Interleaved by Line.	
	*	273	296		RECORD DATA	
44		273	274	I2	Number of physical records per line	$1
45		275	276	I2	Number of physical records per multispectral line in this file : $n for BIL and $1 for BSQ	
46		277	280	I4	Number of bytes of prefix data per record	$$20
47		281	288	I8	Number of bytes of image data per record 3500 for quarter,6920 for full frame	
48		289	292	I4	Number of bytes of suffix data per record	$$68
49		293	296	I4	Prefix/suffix repeat flag	$$$$
	*	297	432		PREFIX/SUFFIX DATA LOCATORS	
					The format for an 8 byte ASCII locator should be as follows : Bytes 1-4 = start byte number of the field within prefix/suffix. Bytes 5-6 = length in bytes of the field to be located. Byte 7 = letter 'P' or 'S' indicating the location of field is prefix or suffix. Byte 8 = type of data format A = ASCII B = Binary N = Numeric ASCII	

50	297	304	A8	Scan line number locator	$$$1$4PB
51	305	312	A8	Image(band) number locator	$$$5$4PB
52	313	320	A8	Time of scan line locator	$$$9$4PB
53	321	328	A8	Left-fill count locator	$$13$4PB
54	329	336	A8	Right-fill count locator	$$$174PB
55	337	368	A8	Blanks	$$$$$$$$
56	369	376	A8	Scan line quality code locator	$$$1$8SB
57	377	384	A8	Calibration information locator	$$3728SB
58	385	392	A8	Gain values field locator	$$5704SB
59	393	400	A8	Bias values field locator	$$6104SB
60	401	432	A32	Blanks	
*	433	4320		PIXEL DATA	
61	433	436	I4	Number of left fill bits within pixel	$$$0
62	437	440	I4	Number of right fill bits within pixel	$$$0
63	441	448	I8	Maximum available data range of pixel (from zero)	$$$$$255
64	449	4320	A3872	Blanks	

'MAGERY_VOLUME
MAGERY_FILE
.MAGE_RECORD for Quarter Scene

field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record sequence number	
2	5	5	B1	1st record sub-type code	237
3	6	6	B1	Record type code	237
4	7	7	B1	2nd record sub-type code	219
5	8	8	B1	3rd record sub-type code	9
6	9	12	B4	Record length	3600
PREFIX	* 13	32		PREFIX DATA	
7	13	16	B4	Scan line number	
8	17	20	B4	Image (band) number	
9	21	24	B4	Time in GMT at start of scan in milliseconds Each byte of this field will be set to 255 if GMT timing information is not available.	
10	25	28	B4	Count of left fill pixels The count of left fill pixels includes the pad pixels inserted for geometric corrections, such as earth rotation correction	
11	29	32	B4	Count of right fill pixels	
				IMAGE DATA	
12	33	3532	3500B1	Image pixels	
SUFFIX	*3533	3600		SUFFIX DATA	
SCAN_LINE_Q	*3533	3540		Scan line quality Byte 3533 is the sync loss indicator for the current line. is set to 1 if sync was lost, and to 0 otherwise. Byte 3535 is set to 1 if the video data for the line was substituted by that for another detector. Byte 3534 and bytes 3536 through 3540 are reserved fo local use use quality control flags, and are set to 0 under normal conditions and to 1 if the error condition occurs.	
13	3533	3533	B1	Sync loss indicator	
14	3534	3534	B1	Local use quality code	
15	3535	3535	B1	Detector substitution indicator	
16	3536	3540	B5	Local use quality codes	
17	3541	3544	B4	Counted full-scan line length This is the number of pixels counted in the original geometrically uncorrected scan line.	
18	3545	3548	B4	Embedded line length This is the number of pixels in the scan line determined from the line length information embedded in the video data stream.	
19	3549	3550	B2	Time error from line start to midscan The time error in clock counts from the nominal line start to midscan count of 161,164 can be converted to time error in microseconds	

				by multiplying by 1/(84.903/16).
20	3551	3552	B2	Time error from midscan to line end The time error in clock counts from the nominal midscan to line stop count of 161,165 can be converted to time error in microseconds by multiplying by 1/(84.903/16). The active scan time is given by the expression ((161,165+161,164)-(Field 17 + Field 16) * (1/(84.903/16))) Since pixels for each detector within a line are sampled every 9.611 usecs, the line length is given by (active scan time/9.611).
21	3553	3556	B4	Scan line direction Scan line direction code is 0 for the forward scan and 1 for the reverse scan.
22	3557	3560	B4	Current scan line length This is the number of scene pixels following the left fill pixels. Field 10 + Field 11 + Field 19 = Field 11 of Table 3.3.1.2.
23	3561	3568	B8	Satellite time code at start of scan The satellite time code is stored in 8 binary bytes as follows : Hundreds of days Tens of days, days Tens of hours, hours Tens of minutes, minutes Tens of seconds, seconds Tenths of seconds, hundredths of seconds Milliseconds, tenths of milliseconds Hundredths of milliseconds and thousandths of milliseconds.
CAL_INF	*3569	3596		Calibration information
24	3569	3569	B1	Detector identification The detector numbering sequence within each spectral band is 1 thru 16, where detector 16 is the most northerly.
25	3570	3570	B1	Calibration lamp value quality The calibration lamp value quality flag takes one of the following values: 0 - good 1 - not used 2 - not available.
26	3571	3571	B1	Calibration lamp state The calibration lamp state identifies which of the eight possible states is being sampled in field 29 (zero fill for band 6).
27	3572	3572	B1	Calibration state sequence number Each calibration lamp state lasts for 40 scans, and this field gives the sequence number in the range 1 to 40. (For radiometric calibration purposes, the first seven values at any one calibration state should not be used). This field is zero-filled for band 6.
28	3573	3576	I4	Low level calibration value (thousandths of levels) For bands 1 through 5 and 7, this is the zero-radiance calibration level which is output during the shutter-closed period.

				For band 6, this is the detector-measured temperature of the shutter surface during the dc-restore calibration period.
29	3577	3580	I4	High level calibration value (thousandths of levels) For bands 1 through 5 and 7, this is the average over thirty contiguous pixels in the centre of the calibration wedge. For band 6, this is the temperature of the temperature-controlled blackbody. The calibration shutter and blackbody temperatures referenced in fields 28 and 29 can be found in the TM housekeeping data record with sequence number 1.
30	3581	3584	I4	Cal. lamp computed gain value (millionths of units)
31	3585	3588	I4	Cal. lamp computed bias value (millionths of units)
32	3589	3592	I4	Applied gain value (millionths of units)
33	3593	3596	I4	Applied bias value (millionths of units) The gain and bias values are stored as 2's complement binary values in millionths of units. Fields 30 and 31 are the computed gain and bias using either onboard calibration device or default values. Fields 32 and 33 are the final gain and bias applied to the data from the specified detector.
34	3597	3600	I4	Local use This field is designated as a local use area, where all fields should be recorded in binary.

MAGERY_VOLUME
MAGERY_FILE
MAGE_RECORD for Full Scene

ield or field-group name		start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
	1	1	4	B4	Record sequence number	
	2	5	5	B1	1st record sub-type code	237
	3	6	6	B1	Record type code	237
	4	7	7	B1	2nd record sub-type code	219
	5	8	8	B1	3rd record sub-type code	9
	6	9	12	B4	Record length	7020
PREFIX		* 13	32		PREFIX DATA	
	7	13	16	B4	Scan line number	
	8	17	20	B4	Image (band) number	
	9	21	24	B4	Time in GMT at start of scan in milliseconds Each byte of this field will be set to 255 if GMT timing information is not available.	
	10	25	28	B4	Count of left fill pixels The count of left fill pixels includes the pad pixels inserted for geometric corrections, such as earth rotation correction	
	11	29	32	B4	Count of right fill pixels	
					IMAGE DATA	
	12	33	6952	6920B1	Image pixels	
SUFFIX		*6953	7020		SUFFIX DATA	
SCAN_LINE_Q		*6953	6960		Scan line quality Byte 6953 is the sync loss indicator for the current line. is set to 1 if sync was lost, and to 0 otherwise. Byte 6955 is set to 1 if the video data for the line was substituted by that for another detector. Byte 6954 and bytes 6956 through 6960 are reserved fo local use use quality control flags, and are set to 0 under normal conditions and to 1 if the error condition occurs.	
	13	6953	6953	B1	Sync loss indicator	
	14	6954	6954	B1	Local use quality code	
	15	6055	6055	B1	Detector substitution indicator	
	16	6056	6960	B5	Local use quality codes	
	17	6961	6964	B4	Counted full-scan line length This is the number of pixels counted in the original geometrically uncorrected scan line.	
	18	6965	6968	B4	Embedded line length This is the number of pixels in the scan line determined from the line length information embedded in the video data stream.	
	19	6969	6970	B2	Time error from line start to midscan The time error in clock counts from the nominal line start to midscan count of 161,164 can be converted to time error in microseconds	

				by multiplying by 1/(84.903/16).
20	6971	6972	B2	Time error from midscan to line end The time error in clock counts from the nominal midscan to line stop count of 161,165 can be converted to time error in microseconds by multiplying by 1/(84.903/16). The active scan time is given by the expression ((161,165+161,164)-(Field 17 + Field 16) * (1/(84.903/16))) Since pixels for each detector within a line are sampled every 9.611 usecs, the line length is given by (active scan time/9.611).
21	6973	6976	B4	Scan line direction Scan line direction code is 0 for the forward scan and 1 for the reverse scan.
22	6977	6980	B4	Current scan line length This is the number of scene pixels following the left fill pixels. Field 10 + Field 11 + Field 19 = Field 11 of Table 3.3.1.2.
23	6981	6988	B8	Satellite time code at start of scan The satellite time code is stored in 8 binary bytes as follows : Hundreds of days Tens of days, days Tens of hours, hours Tens of minutes, minutes Tens of seconds, seconds Tenths of seconds, hundredths of seconds Milliseconds, tenths of milliseconds Hundredths of milliseconds and thousandths of milliseconds.
CAL INF	*6989	7016		Calibration information
24	6989	6989	B1	Detector identification The detector numbering sequence within each spectral band is 1 thru 16, where detector 16 is the most northerly.
25	6990	6990	B1	Calibration lamp value quality The calibration lamp value quality flag takes one of the following values: 0 - good 1 - not used 2 - not available.
26	6991	6991	B1	Calibration lamp state The calibration lamp state identifies which of the eight possible states is being sampled in field 29 (zero fill for band 6).
27	6992	6992	B1	Calibration state sequence number Each calibration lamp state lasts for 40 scans, and this field gives the sequence number in the range 1 to 40. (For radiometric calibration purposes, the first seven values at any one calibration state should not be used). This field is zero-filled for band 6.
28	6993	6996	I4	Low level calibration value (thousandths of levels) For bands 1 through 5 and 7, this is the zero-radiance calibration level which is output during the shutter-closed period.

				For band 6, this is the detector-measured temperature of the shutter surface during the dc-restore calibration period.
29	6997	7000	I4	High level calibration value (thousandths of levels) For bands 1 through 5 and 7, this is the average over thirty contiguous pixels in the centre of the calibration wedge. For band 6, this is the temperature of the temperature-controlled blackbody. The calibration shutter and blackbody temperatures referenced in fields 28 and 29 can be found in the TM housekeeping data record with sequence number 1.
30	7001	7004	I4	Cal. lamp computed gain value (millionths of units)
31	7005	7008	I4	Cal. lamp computed bias value (millionths of units)
32	7009	7012	I4	Applied gain value (millionths of units)
33	7013	7016	I4	Applied bias value (millionths of units) The gain and bias values are stored as 2's complement binary values in millionths of units. Fields 30 and 31 are the computed gain and bias using either onboard calibration device or default values. Fields 32 and 33 are the final gain and bias applied to the data from the specified detector.
34	7017	7020	I4	Local use This field is designated as a local use area, where all fields should be recorded in binary.

3.4 IMAGERY LOGICAL VOLUME - TRAILER FILE

The trailer file is of the class TRAILER FILE with the class code TRAI. Each trailer file contains the following record types described in the following tables :

1. FILE DESCRIPTOR RECORD

2. TRAILER RECORD
In order to maintain a manageable record size, there is one set of four trailer records for each of the bands accommodated in the accompanying image data file.
Each trailer record contains raw data histograms for 4 detectors for that band. In addition, it contains the parity error count and a quality summary.

IMAGERY_VOLUME
TRAILER_FILE
FILE_DESCRIPTOR_RECORD

Field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
FDR_FIXED_SEGM *	1	180		FILE DESCRIPTOR RECORD FIXED SEGMENT	
1	1	4	B4	Record Sequence Number	1
2	5	5	B1	1st record sub-type code (DECIMAL)	63
3	6	6	B1	Record type code (DECIMAL)	192
4	7	7	B1	2nd record sub-type code (DECIMAL)	18
5	8	8	B1	3rd record sub-type code (DECIMAL)	18
6	9	12	B4	Length of this record	4320
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	28	A12	Control Document Number for this Data File Format	GES$10490$$$
10	29	30	A2	Control Document Revision Number <NN>,where NN=01-99	
11	31	32	A2	File Design Descriptor Revision Letter <XX>, (Initially '$A',then '$B',etc.)	
12	33	44	A12	Software Release Number TMFR-CCT-<XXX>, initiall XXX=001,then 002,etc	
13	45	48	I4	File Number 3 for BIL; 3,6,9,12,15,18 or 21 for BSQ	
14	49	64	A16	File Name LS5$TM<LL>TRAIBSQm or LS5$TM<LL>TRAIBIL$ This field can take as value 2*8*7 combinations e.g. LS4TM2TRAIBSQ6,where m is the band number to which the associated imagery relates,and <LL> is the level of corrections applied.	
15	65	68	A4	Record Sequence and Location Type Flag	FSZQ
16	69	76	I8	Sequence Number Location	$$$$$$$1
17	77	80	I4	Sequence Number Field Length	$$$4
18	81	84	A4	Record Code and Location Type Flag	FTYP
19	85	92	I8	Record Code Location	$$$$$$$5
20	93	96	I4	Record Code Field Length	$$$4
21	97	100	A4	Record Length and Location Type Flag	FLGT
22	101	108	I8	Record Length Location	$$$$$$$9
23	109	112	I4	Record Length Field Length	$$$4
24	113	113	A1	Flag indicating that data interpretation information is included within the file descriptor record. <X> ,where X=Y OR N ,for YES or NO	
25	114	114	A1	Flag indicating that data interpretation information is included within the file in record(s) other than the descriptor <X> ,where X=Y OR N ,for YES or NO	
26	115	115	A1	Flag indicating that data display information is included within the file descriptor record. <X> ,where X=Y OR N ,for YES or NO	
27	116	116	A1	Flag indicating that data display information is included within the file in record(s) other than the file descriptor. <X> ,where X=Y OR N ,for YES or NO	

28		117	180		Reserved Segment	Blanks
FDR_VARIA_SEGM	*	181	4320		FILE DESCRIPTOR RECORD VARIABLE SEGMENT	
29		181	186	I6	Number of trailer records (4*n) where n is the number of bands	
30		187	192	I6	Trailer record length	$$4320
31		193	216	A24	Reserved (Blanks)	
32		217	232	A16	Quality indicator summary counts locator	$$$$$2$$4125$20B
33		233	248	A16	Quality code summary map field locator	$$$$$2$$4164157B
34		249	4320	A4072	Blanks	

:MAGERY_VOLUME
:RAILER_FILE
:RAILER_RECORD

ield or field-group name		start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1		1	4	B4	Record sequence number	
2		5	5	B1	1st record sub-type code	18
3		6	6	B1	Record type code	246
4		7	7	B1	2nd record sub-type code	18
5		8	8	B1	3rd record sub-type code	9
6		9	12	B4	Record length	4320
7		13	16	I4	Trailer record sequence number	
8		17	20	I4	Sequence number of trailer record within band Since one record of 4320 bytes can hold the histograms of only 4 detectors,four trailer records are required for each mirror scan direction of each spectral band. For band 6, full scan lines are replicated four times. Hence, 16 histograms will be provided for each mirror scan direction of band 6.	
TRA_DAT	*	21	4320		TRAILER DATA	
9		21	4116	4096B1	Histograms for 4 detectors within the band This field contains the histograms of the RAW data for 4 detectors for the band, and consists of 256 data items for each detector, where each data item occupies 4 bytes and contains the count in binary, of the number of occurrences of that value (range 0 to 255) in the RAW scene.	
10		4117	4020	I4	Parity error count	
11		4021	4320	A300	Quality summary, and LOCAL USE This field may be used for a free format description of the quality of the data.	

3.5 SUPPLEMENTAL LOGICAL VOLUME - VOLUME DIRECTORY FILE

The Volume Directory file is the first file of every TM logical volume and consists of a Volume Descriptor Record, File Pointer Records and a Text Record. According to standard format family conventions, the volume directory file is repeated, with certain fields updated, whenever a logical volume spans more than one physical volume. Those fields which are modified when the volume directory is repeated at the start of a new physical volume are identified with notes in the detailed record layout tables.
There are three record types in this file and their description and content is contained in the following tables :

1. VOLUME DESCRIPTOR RECORD
There is one file class in the supplemental logical volume, and the File Pointer Record contains the name and code of that file class, as follows:

CLASS NAME	CLASS CODE	FILE CONTENT
SUPPLEMENTAL FILE	SUPP	Interval header, Interval-related ancillary.

2. FILE POINTER RECORD FOR SUPPLEMENTAL FILE
3. TEXT RECORD

UPPLEMENTAL VOLUME
OLUME_DIRECTORY_FILE
OLUME_DESCRIPTOR_RECORD

ield or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Sequence Number	1
2	5	5	B1	1st record sub-type code (Decimal)	192
3	6	6	B1	Record type code (Decimal)	192
4	7	7	B1	2nd record sub-type code (Decimal)	18
5	8	8	B1	3rd record sub-type code (Decimal)	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	28	A12	Superstructure control document number	CCB-CCT-0002
10	29	30	A2	Superstructure control document revision number <XX> (initially '$C')	
11	31	32	A2	Superstructure record format revision letter <XX> (initially '$A',then '$B',ext...)	
12	33	44	A12	Software release number TMFR-CCT-<XXX> (initially XXX = 001,then 002,ext.)	
13	45	60	A16	identifier of logical volume containing this volume descriptor : <MMSYYDDDPPPRRRAA>	
14	61	76	A16	Physical Volume ID : <AAQYYDDDHHMMSSMM>	
15	77	92	A16	Volume Set ID	LANDSAT5TM$$$$
16	93	94	I2	Number of Physical Volumes in the Set <$N> where N=1,or2,or3.	
17	95	96	I2	Physical Volume Number, Start of Logical Volume	$1
18	97	98	I2	Physical Volume Number, End of Logical Volume <$N> where N=1,or2,or3.	
19	99	100	I2	Physical Volume sequence number (i.e. of current tape) <$N> where N=1,or2,or3.	
20	101	104	I4	First Referenced File Number in this Physical Volume	$$$1
21	105	108	I4	Logical Volume Number within Volume Set	$$$2
22	109	112	I4	Logical Volume Number within Physical Volume	$$$2
23	113	120	A8	Logical Volume Creation Date <YYYYMMDD>	
24	121	128	A8	Logical Volume Creation Time <HHMMSSXX>	
25	129	140	A12	Logical Volume Generating Country ITA - FUCINO or SWE - KIRUNA	
26	141	148	A8	Logical Volume Generating Agency	ESA-ESRO
27	149	160	A12	Logical Volume Generating Facility ITA - FUCINO or SWE - KIRUNA	
28	161	164	I4	Number of Pointer Records in Volume Directory	1
29	165	168	I4	Number of Records in Volume Directory	3
30	169	260	A92	Volume Descriptor Spare Segment	Blanks
31	261	360	A100	Local Use Segment	Blanks

IMAGERY_VOLUME
VOLUME_DIRECTORY_FILE
SUPPLEMENTAL_FILE_POINTER_RECORD

Field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Sequence Number	2
2	5	5	B1	1st record sub-type code	219
3	6	6	B1	Record type code	192
4	7	7	B1	2nd record sub-type code	18
5	8	8	B1	3rd record sub-type code	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	20	I4	Referenced File Number	1
10	21	36	A16	Referenced File Name LS4$TM$$SUPP$$$$ 5	
11	37	64	A28	Referenced File Class	SUPPLEMENTALFILE
12	65	68	A4	Referenced File Class Code	SUPP
13	69	96	A28	Referenced File Data Type	MIXED$BINARY$AND$ASCII
14	97	100	A4	Referenced File Data Type Code	MBAA
15	101	108	I8	Number of Records in Referenced File This field is calculated according to the requested number of interval-related ancillary records.	
16	109	116	I8	Referenced File - Descriptor Record Length	540
17	117	124	I8	Referenced File Maximum Record Length	6300
18	125	136	A12	Referenced File Record Length Type	VARIA$LENGTH
19	137	140	A4	Referenced File Record Length Type Code	VARI
20	141	142	I2	Referenced File Physical Volume Number, Start of File	$1
21	143	144	I2	Referenced File Physical Volume Number, End of File	$1
22	145	152	I2	Referenced File Portion, 1st Record Number for this Physical Volume	$1
23	153	160	I8	Referenced file portion, last record number for this physical volume This field is calculated according to the requested number of interval-related ancillary records.	
24	161	260	A100	Pointer Spare Segment	Blanks
25	261	360	A100	Local Use Segment	Blanks

SUPPLEMENTAL_VOLUME
/OLUME_DIRECTORY_FILE
:EXT_RECORD

ield or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Number	
2	5	5	B1	1st record sub-type code	18
3	6	6	B1	record type code, always	63
4	7	7	B1	2nd record sub-type code	18
5	8	8	B1	3rd record sub-type code	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC flag for this record	A$
8	15	16	A2	Continuation flag. This field contains two blanks unless the information of this record is continued on a following record, in which case, the field is coded C$.	
9	17	66	A50	Supplemental file description LANDSAT$<S>$THEMATIC$MAPPER$SUPPLEMENTAL$ DATA$FILE<CRLF> where <S> is the number of the LANDSAT mission	
10	67	124	A58	Location and date/time of product creation PROCESSED:ITAPUCINOFORESA$EARTHNET$ON$ SWE$KIRUNA SPA$MASPAL <YYYYMMDD>$$$$$$$$$$$$<CRLF> The date of recording the Logical Volume is stored in the form <YYYYMMDD>, where YYYY is the year, MM is the month and DD is the day .	
11	125	173	A49	Orbit identification ORBIT$$:$$$<BBBBBBBB>$$$$$$$$$$IMAGEDON <YYYYMMDD><CRLF> The orbit is an 8-byte ASCII Numeric string, <BBBBBBBB>. In addition, the date of recording of the original Landsat TM image is stored in the form <YYYYMMDD>,same format as field 10.	
12	174	216	A43	Physical tape identification TAPE$ID:$$<IINNNN>$$$$$$$$$$$$TAPE$ <MM>OF<LL><CRLF> The physical tape id. is a 16 character field e.g. IS1234.....,followed by the tape sequence number, <MM>, within the Physical Volume Set containing a total of <LL> tapes.	
13	217	360	A144	Blanks	

3.6 SUPPLEMENTAL LOGICAL VOLUME - SUPPLEMENTAL FILE

The Supplemental file is the only data file in the supplemental logical volume, and is of the class SUPPLEMENTAL FILE with the class code SUPP. There are five records types in this file whose description and content are contained in the following tables :

1. FILE DESCRIPTOR RECORD
2. INTERVAL HEADER RECORD
3. TM HOUSEKEEPING DATA ANCILLARY RECORD
4. EPHEMERIS AND ATTITUDE ANCILLARY RECORD
5. RAW JITTER MEASUREMENTS ANCILLARY RECORD

UPPLEMENTAL_VOLUME
UPPLEMENTAL_FILE
ILE_DESCRIPTOR_RECORD

ield or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
FDR_FIXED_SEGM *	1	180		FILE DESCRIPTOR RECORD FIXED SEGMENT	
1	1	4	B4	Record Sequence Number	1
2	5	5	B1	1st record sub-type code (DECIMAL)	63
3	6	6	B1	Record type code (DECIMAL)	192
4	7	7	B1	2nd record sub-type code (DECIMAL)	18
5	8	8	B1	3rd record sub-type code (DECIMAL)	18
6	9	12	B4	Length of this record	540
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	28	A12	Control Document Number for this Data File Format	GES$10490$$$
10	29	30	A2	Control Document Revision Number <NN>,where NN=01-99	
11	31	32	A2	File Design Descriptor Revision Letter <XX>, (Initially '$A',then '$B',etc.)	
12	33	44	A12	Software Release Number TMFR-CCT-<XXX>, initiall XXX=001,then 002,etc	
13	45	48	I4	File Number	$$$1
14	49	64	A16	File Name LS5$TM<LL>SUPP$$$$ where <LL> is the level of corrections applied.	
15	65	68	A4	Record Sequence and Location Type Flag	FSEQ
16	69	76	I8	Sequence Number Location	$$$$$$$1
17	77	80	I4	Sequence Number Field Length	$$$4
18	81	84	A4	Record Code and Location Type Flag	FTYP
19	85	92	I8	Record Code Location	$$$$$$$5
20	93	96	I4	Record Code Field Length	$$$4
21	97	100	A4	Record Length and Location Type Flag	FLGT
22	101	108	I8	Record Length Location	$$$$$$$9
23	109	112	I4	Record Length Field Length	$$$4
24	113	113	A1	Flag indicating that data interpretation information is included within the file descriptor record. <X> ,where X=Y OR N ,for YES or NO	
25	114	114	A1	Flag indicating that data interpretation information is included within the file in record(s) other than the descriptor <X> ,where X=Y OR N ,for YES or NO	
26	115	115	A1	Flag indicating that data display information is included within the file descriptor record. <X> ,where X=Y OR N ,for YES or NO	
27	116	116	A1	Flag indicating that data display information is included within the file in record(s) other than the file descriptor. <X> ,where X=Y OR N ,for YES or NO	
28	117	180		Reserved Segment	Blanks
FDR_VARIA_SEGM *	181	540		FILE DESCRIPTOR RECORD VARIABLE SEGMENT	

29	181	186	I6	Number of interval-related header records	$$$$$1
30	187	192	I6	Interval-related header record length	$$1800
31	193	198	I6	Number of TM housekeeping data records	
32	199	204	I6	TM housekeeping data record length	$$2880
33	205	210	I6	Number of processed ephemeris data records	
34	211	216	I6	Processed ephemeris data record length	$$4680
35	217	222	I6	Number of scene definition (scene header) records	
36	223	228	I6	Scene definition record length	
37	229	234	I6	Number of scene quality data records	
38	235	240	I6	Scene quality data record length	
39	241	246	I6	Number of geometric modelling (map projection) data records	
40	247	252	I6	Geometric modelling data record length	
41	253	258	I6	Number of sparse matrices records	
42	259	264	I6	Sparse matrices record length	
43	265	270	I6	Number of GCD mirror scan start time records	
44	271	276	I6	GCD mirror scan start time record length	
45	277	282	I6	Number of high frequency along scan matrix records (raw jitter measurements)	
46	283	288	I6	High frequency along scan matrix record length	$$6300
47	289	294	I6	Number of high frequency cross scan matrix records	
48	295	300	I6	High frequency cross scan matrix record length	
49	301	306	I6	Number of annotation records	
50	307	312	I6	Annotation record length	
51	313	318	I6	Number of mission telemetry ancillary records	
52	319	324	I6	Mission telemetry ancillary record length	
53	325	330	I6	Number of local use records	
54	331	336	I6	Local use record length	
55	337	352	A16	Interval data start time locator	$$$$$2$$$$25$16A
56	353	368	A16	Interval data stop time locator	$$$$$2$$$$41$16A
57	369	384	A16	Orbit field locator	$$$$$2$$$$93$$8A
58	385	540	A156	Spare (Blanks)	

:PPLEMENTAL_VOLUME
:PPLEMENTAL_FILE
:TERVAL_HEADER_RECORD

ield or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	sequence number	
2	5	5	B1	1st record sub-type code	73
3	6	6	B1	Record type code	18
4	7	7	B1	2nd record sub-type code	73
5	8	8	B1	3rd record sub-type code	36
6	9	12	B4	Length of this record	1800
7	13	16	I4	Interval header record sequence number	
8	17	20	A4	Blanks	$$$$
INT_HEA_DATA *	21	1800		INTERVAL HEADER DATA	
9	21	24	A4	Blanks	$$$$
10	25	40		Input scene start time All times are made up as follows : <DDDDHHMMMMMMTTT>$ where DDD is the day of the year MMMMMMM are the milliseconds of day TTT are the thousands of milliseconds Fields 10 and 11 may be blank filled if there is no associated imagery logical volume.	
11	41	56		Input scene stop time	
12	57	72		PCD telemetry start time	
13	73	88		PCD telemetry stop time	
14	89	92		Number of PCD major frames	
15	93	100		Orbit number	
16	101	1800		Spare	

SUPPLEMENTAL_VOLUME
SUPPLEMENTAL_FILE
TM_HOUSEKEEPING_DATA_ANCILLARY_RECORD

field or field-group name		start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1		1	4	B4	sequence number	
2		5	5	B1	1st record sub-type code	121
3		6	6	B1	Record type code	36
4		7	7	B1	2nd record sub-type code	73
5		8	8	B1	3rd record sub-type code	36
6		9	12	B4	Length of this record	2880
7		13	16	I4	TM housekeeping data record sequence number Field 7 contains the sequence number of this ancillary record within the set of interval related ancillary records of this type, starting from 1.	
8		17	20	I4	PCD major frame identifier Field 8 of PCD related records is defined to contain EITHER flags to indicate which elements within this record have been updated within the current PCD major frame, OR the sequence number of this interval related ancillary record WITHIN the PCD major frame. This TM housekeeping ancillary record has been defined for the telemetry data which is stored in the third PCD major frame after the telemetry major frame pulse, and will be identified by a sequence number of 1. If telemetry data from the first major frame after the telemetry major frame pulse is required, then it will be stored in a record with an identical format but with the sequence number 2.	
	*	21	36		PCD MAJOR FRAME START TIME	
9		21	24	I4	Day of year at start of PCD frame (STC)	
10		25	32	I3	Milliseconds of day at start of PCD frame (STC)	
11		33	35	I3	Thousandths of Milliseconds of day at start of PCD frame (STC)	
12		36	36		Blank	
	*	37	2880		TM HOUSEKEEPING DATA In common with other interval related ancillary records, the TM housekeeping data fields supply the time offset from the start of the PCD major frame, the observation itself, and sufficient auxiliary information to convert the observation to engineering units.	
	*	37	122		Blackbody temperature Degrees C	
13		37	46	I10	TM housekeeping sample time offset (microseconds) Gives the time offset of the observation since the start of the PCD major frame, in microseconds.	
14		47	50	I4	TM housekeeping sample	
					NOTE : Fields 15 through 20 contain coefficients A0, A1, A2, A3 A4 and A5 respectively, which are required to convert the telemetry function from counts (C) to engineering units by using the following equation: EU = A0 + A1*C + A2*C**2 + A3*C**3 + A4*C**4 + A5*C**5	

15	51	62	E12.6	A0 coefficient
16	63	74	E12.6	A1 coefficient
17	75	86	E12.6	A2 coefficient
18	87	98	E12.6	A3 coefficient
19	99	110	E12.6	A4 coefficient
20	111	122	E12.6	A5 coefficient

NOTE :
Data fields 21 thru 51 are constructed from 86 bytes in an identical fashion to group of fields (13 to 20).

21	123	208	Silicon focal plane assembly temperature (FPA) Degrees C
22	209	294	Calibration shutter temperature Degrees C
23	295	380	Unused
24	381	466	Baffle temperature Degrees C
25	467	552	Cold stage FPA temperature Degrees K
26	553	638	Unused
27	639	724	Unused
28	725	810	Scan line corrector temperature Degrees C
29	811	896	Calibration shutter hub temperature Degrees C
30	897	982	Unused
31	983	1068	Unused
32	1069	1154	Relay optics temperature Degrees C
33	1155	1240	Unused
34	1241	1326	Unused
35	1327	1412	Unused
36	1413	1498	Unused (Unpacked as serial word B)
37	1499	1584	Unused
38	1585	1670	Unused (Unpacked as serial word D)
39	1671	1756	Unused (Unpacked as serial word E)
40	1757	1842	Unused (Unpacked as serial word F)
41	1843	1928	Unused (Unpacked as serial word G)
42	1929	2014	Unused
43	2015	2100	Unused (Unpacked as serial word L)
44	2101	2186	Primary mirror temperature Degrees C
45	2187	2272	Unused
46	2273	2358	Secondary mirror temperature Degrees C
47	2359	2444	Unused
48	2445	2530	Unused
49	2531	2616	Unused
50	2617	2702	Unused
51	2703	2788	Unused
52	2789	2836	Serial words B,D,E,F,G,L The content of serial words B,D,E,F,G and L extracted from minor frames 32,34,35,36,37 and 39 is reproduced here in an expanded form, with 1 byte beeing used to store the data from each bit of the serial word. Each bute can take the ASCII Numeric value of : 0 = OFF or 1 = ON.
53	2837	2880	Spare

SUPPLEMENTAL_VOLUME
SUPPLEMENTAL_FILE
EPHEMERIS_AND_ATTITUDE_ANCILLARY_RECORD

field or field-group name		start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1		1	4	B4	sequence number	
2		5	5	B1	1st record sub-type code	248
3		6	6	B1	Record type code	36
4		7	7	B1	2nd record sub-type code	73
5		8	8	B1	3rd record sub-type code	36
6		9	12	B4	Length of this record	4680
7		13	16	I4	Ephemeris and attitude data record sequence number Sequence number of the ancillary record within the set of interval related ancillary records of this type.	
8		17	20	4I1	Four flags indicating whether the component was updated in the current PCD major frame. Values are 0/1 representing NO/YES Byte 17 - ephemeris flag Byte 18 - attitude flag Byte 19 - gyro flag Byte 20 - gyro drift flag NOTE : Field 8 of PCD related records is defined to contain EITHER flags to indicate which elements within this record have been updated within the current PCD major frame, OR the sequence number of this interval related ancillary record WITHIN the PCD major frame. For the ephemeris and attitude ancillary record, this field contains update flags, as follows: Ephemeris data is updated in alternate major frames, Attitude data is updated in every major frame, Gyro data is updated 64 times in every major frame at equal time intervals, Gyro drift data is updated once in (approximately) every sixteenth major frame.	
	*	21	36		PCD MAJOR FRAME START TIME	
9		21	24	I4	Day of year at start of PCD frame (STC)	
10		25	32	I8	Milliseconds of day at start of PCD frame (STC)	
11		33	35	I3	Thousandths of milliseconds of day at start of PCD frame (STC)	
12		36	36		Blank	
	*	37	178		EPHEMERIS DATA NOTE : In common with other interval related ancillary records, the ephemeris and attitude data fields supply the time offset for the observation. The time since the start of the PCD major frame is given in microseconds.	
13		37	46	I10	Ephemeris measurement time offset (microseconds)	
14		47	68	D22.15	Spacecraft position component X	
15		69	90	D22.15	Spacecraft position component Y	
16		91	112	D22.15	Spacecraft position component Z	
17		113	134	D22.15	Spacecraft velocity component X	
18		135	156	D22.15	Spacecraft velocity component Y	

19		157	178	D22.15 Spacecraft velocity component Z

NOTE : UNITS AND FRAME OF REFERENCE
All components are stored with reference to the earth-centred inertial (ECI) frame. In the ECITOD system, the Z-axis is along a line from the centre of the earth coincident with the true earth spin axis, positive north. The X-axis is along a line from the centre of the earth toward the intersection of the true equator and true ecliptic of date. The Y-axis completes the right-handed set.
The ECITOD system varies slowly with respect to a truly inertial system due to precession and nutation of the earth's axis and precession of the plane of the ecliptic. These variations occur sufficiently slowly that the ECITOD system can be considered to be inertial over a span of a few days for attitude control purposes.
Spacecraft position components are given in ECITOD coordinates in metres.
Spacecraft velocity components are given in metres/millisecond.

*	179	276		ATTITUDE DATA

NOTE :
Attitude is Euler parameters EPA1, EPA2, EPA3 and EPA4 that specify vehicle attitude relative to the ECI frame. The parameters are components of the reference quaternion (as propagated from gyro data) which defines spacecraft attitude. Components 1 through 3 define the Eigen axis of rotation in ECI coordinates, and component 4 defines rotation about that axis, as follows;

EPA1 = AX * sin(O/2)
EPA2 = AY * sin(O/2)
EPA3 = AZ * sin(O/2)
EPA4 = cos(O/2)
where A = Eigenaxis of rotation, and O = magnitude of rotation.

20		179	188	I10 Attitude measurement time offset (microseconds)
21		189	210	D22.15 EPA1
22		211	232	D22.15 EPA2
23		233	254	D22.15 EPA3
24		255	276	D22.15 EPA4
	*	277	4510	GYRO DATA
25		277	286	I10 Gyro measurement (first measurement) time offset (microseconds)
				Time of measurement of gyro drift is indeterminate.
26		287	4510	64* 64 sets of gyro measurements, where each set
				3D22.15 consists of measurements for each of 3 axes.
				Gyro output units are arc-seconds of angle.
	*	4511	4680	GYRO DRIFT DATA
				Gyro drift output units are radians/512 msecs.
27		4511	4520	I10 Gyro drift measurement time offset (microseconds)
28		4521	4542	D22.15 Gyro drift - x axis
29		4543	4564	D22.15 Gyro drift - y axis
30		4565	4586	D22.15 Gyro drift - z axis
31		4587	4680	Spare

SUPPLEMENTAL_VOLUME
SUPPLEMENTAL_FILE
RAW_JITTER_MEASUREMENTS_ANCILLARY_RECORD

field or field-group name		start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1		1	4	B4	sequence number	
2		5	5	B1	1st record sub-type code	229
3		6	6	B1	Record type code	36
4		7	7	B1	2nd record sub-type code	146
5		8	8	B1	3rd record sub-type code	36
6		9	12	B4	Length of this record	6300
7		13	16	I4	Raw jitter measurement record sequence number Sequence number of this ancillary record within the set of interval related ancillary records of this type	
8		17	20	I4	Sequence number within PCD major frame Field 8 of PCD related records is defined to contain EITHER flags to indicate which elements within this record have been updated within the current PCD major frame, OR the sequence number of this interval related ancillary record WITHIN the PCD major frame. For the raw jitter measurements ancillary record, field 8 contains the sequence number of this record type within the PCD major frame.	
	*	21	36		PCD MAJOR FRAME START TIME	
9		21	24	I4	Day of year at start of PCD frame (STC)	
10		25	32	I8	Milliseconds of day at start of PCD frame (STC)	
11		33	35	I3	Thousandths of milliseconds at start of PCD frame	
12		36	36	A1	Blank	
	*	37	124		ADS TEMPERATURE DATA Time offsets in microseconds and temperature of the four ADS temperature measurements.	
13		37	46	I10	ADS temperature (1) time offset (microseconds)	
14		47	58	E12.5	ADS temperature (1) degrees C	
15		59	68	I10	ADS temperature (2) time offset (microseconds)	
16		69	80	E12.5	ADS temperature (2) degrees C	
17		81	90	I10	ADS temperature (3) time offset (microseconds)	
18		91	102	E12.5	ADS temperature (3) degrees C	
19		103	112	I10	ADS temperature (4) time offset (microseconds)	
20		113	124	E12.5	ADS temperature (4) degrees C	
	*	125	6300		ADS MEASUREMENTS Fields 21, 22 and 23 give the time offset of the observation since the start of the major frame, in microseconds. Since there are measurements for 3 ADS axes, the time offset is provided for the first measurement of EACH of the three axes. The time interval between successive measurements is 2 msecs.	
21		125	134	I10	ADS measurement (1),axis 1,time offset (microseconds)	
22		135	144	I10	ADS measurement (1),axis 2,time offset (microseconds)	
23		145	154	I10	ADS measurement (1),axis 3,time offset (microseconds)	
24		155	6298	1024*B2	1024 ADS measurements, each measurement consisting of 1 sample of each of 3 axes, 2 bytes each sample. Since each axis of the ADS is sampled every 2 msecs, there will be a total of 2048 ADS measurements per PCD major frame.	

			Each jitter measurements ancillary record therefore contains 1024 samples from EACH of the three axes, which are roll, pitch and yaw respectively. Each sample is stored as a 2-byte binary integer, where the most significant bit of the first byte is the sign, and the least significant bit represents (250/2**11) microradians. Total requirements for one PCD major frame are 2 records, each of length 6300 bytes.
25	6299	6300	Spare

3.7 CALIBRATION LOGICAL VOLUME - VOLUME DIRECTORY FILE

The Volume Directory file is the first file of every TM logical volume and consists of a Volume Descriptor Record, File Pointer Records and a Text Record. According to standard format family conventions, the volume directory file is repeated, with certain fields updated, whenever a logical volume spans more than one physical volume. Those fields which are modified when the volume directory is repeated at the start of a new physical volume are identified with notes in the detailed record layout tables.
There are three record types in this file and their description and content is contained in the following tables :

1. VOLUME DESCRIPTOR RECORD

There is one file class in the calibration logical volume, and the File Pointer Record contains the name and code of that file class, as follows:

CLASS NAME	CLASS CODE	FILE CONTENT
CALIBRATION FILE	CALB	Interval header, Interval-related ancillary.

2. FILE POINTER RECORD FOR CALIBRATION FILE
3. TEXT RECORD

:ALIBRATION VOLUME
.OLUME DIRECTORY FILE
/OLUME DESCRIPTOR RECORD

ield or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Sequence Number	1
2	5	5	B1	1st record sub-type code (Decimal)	192
3	6	6	B1	Record type code (Decimal)	192
4	7	7	B1	2nd record sub-type code (Decimal)	18
5	8	8	B1	3rd record sub-type code (Decimal)	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	28	A12	Superstructure control document number	CCB-CCT-0002
10	29	30	A2	Superstructure control document revision number <XX> (initially '$C')	
11	31	32	A2	Superstructure record format revision letter <XX> (initially '$A',then '$B',ext...)	
12	33	44	A12	Software release number TMFR-CCT-<XXX> (initially XXX = 001,then 002,ext.)	
13	45	60	A16	identifier of logical volume containing this volume descriptor : <MNSYYDDDPPPRRRAA>	
14	61	76	A16	Physical Volume ID : <AAQYYDDDHHMMSSNN>	
15	77	92	A16	Volume Set ID	LANDSAT5TM$$$$
16	93	94	I2	Number of Physical Volumes in the Set <$N> where N=1,or2,or3.	
17	95	96	I2	Physical Volume Number, Start of Logical Volume	$1
18	97	98	I2	Physical Volume Number, End of Logical Volume <$N> where N=1,or2,or3.	
19	99	100	I2	Physical Volume sequence number (i.e. of current tape) <$N> where N=1,or2,or3.	
20	101	104	I4	First Referenced File Number in this Physical Volume	$$$1
21	105	108	I4	Logical Volume Number within Volume Set	$$$3
22	109	112	I4	Logical Volume Number within Physical Volume	$$$3
23	113	120	A8	Logical Volume Creation Date <YYYYMMDD>	
24	121	128	A8	Logical Volume Creation Time <HHMMSSXX>	
25	129	140	A12	Logical Volume Generating Country ITA - FUCINO or SWE - KIRUNA	
26	141	148	A8	Logical Volume Generating Agency	ESA-EPO
27	149	160	A12	Logical Volume Generating Facility ITA - FUCINO or SWE - KIRUNA	
28	161	164	I4	Number of Pointer Records in Volume Directory	1
29	165	168	I4	Number of Records in Volume Directory	3
30	169	260	A92	Volume Descriptor Spare Segment	Blanks
31	261	360	A100	Local Use Segment	Blanks

CALIBRATION_VOLUME
VOLUME_DIRECTORY_FILE
CALIBRATION_FILE_POINTER_RECORD

field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Sequence Number	2
2	5	5	B1	1st record sub-type code	219
3	6	6	B1	Record type code	192
4	7	7	B1	2nd record sub-type code	18
5	8	8	B1	3rd record sub-type code	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	20	I4	Referenced File Number	1
10	21	36	A16	Referenced File Name LS4$TH$$CALB$$$$ 5	
11	37	64	A28	Referenced File Class	CALIBRATION$FILE
12	65	68	A4	Referenced File Class Code	CALB
13	69	96	A28	Referenced File Data Type	MIXED$BINARY$AND$ASCII
14	97	100	A4	Referenced File Data Type Code	MBAA
15	101	108	I8	Number of Records in Referenced File	6401
16	109	116	I8	Referenced File - Descriptor Record Length	6090
17	117	124	I8	Referenced File Maximum Record Length	6090
18	125	136	A12	Referenced File Record Length Type	VARIABLE$LEN
19	137	140	A4	Referenced File Record Length Type Code	VARE
20	141	142	I2	Physical Volume Number containing the first record of the referenced file	
21	143	144	I2	Physical Volume Number containing the last record of the referenced file	
22	145	152	I2	Record Number of the first record appearing in this Physical Volume	1
23	153	156	I4	Length of the Logical Record	870
24	157	160	I4	Blocking Factor	7
25	161	260	A100	Pointer Spare Segment	Blanks
26	261	360	A100	Local Use Segment	Blanks

:ALIBRATION_VOLUME
/OLUME_DIRECTORY_FILE
:EXT_RECORD

Field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Number	
2	5	5	B1	1st record sub-type code	18
3	6	6	B1	record type code, always	63
4	7	7	B1	2nd record sub-type code	18
5	8	8	B1	3rd record sub-type code	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC flag for this record	A$
8	15	16	A2	Continuation flag. This field contains two blanks unless the information of this record is continued on a following record, in which case, the field is coded C$.	
9	17	66	A50	Calibration file description LANDSAT$<S>$THEMATIC$MAPPER$CALIBRATION$$ DATA$FILE<CRLF> where <S> is the number of the LANDSAT mission	
10	67	124	A58	Location and date/time of product creation PROCESSED:ITAFUCINOFORESA$EARTHNET$ON$ <YY>/<MM>/<DD>$$$$$ where YY is the year, MM the month and DD the day.	
11	125	173	A49	Image identification IMAGE IDENTIFICATION$$$AA-BBB-CCC$$$$$$$$$$$$$	
12	174	227	A54	Physical tape identification TAPE$ID:$$<XXNNNN>$$$$$$$$$$$$$TAPE$ <MM>OF<LL> The physical tape id. is a 16 character field e.g. IS1234.....,followed by the tape sequence number, <MM>, within the Physical Volume Set containing a total of <LL> tapes.	
13	228	360	A133	Blanks	

3.8 CALIBRATION VOLUME - CALIBRATION FILE

The Calibration file is the only data file in the calibration logical volume, and is of the class CALIBRATION FILE with the class code CALB. There are two record types in this file and their description and content are contained in the following tables :

1. FILE DESCRIPTOR RECORD
The FDR variable segment gives the number and length of the records in the calibration file,information on the time interval of calibration acquisition, the pointer to the video data.
In addition, locators are given, supplying the location and format of several important data fields within the calibration file.

2. CALIBRATION DATA RECORD

CALIBRATION_VOLUME
CALIBRATION_FILE
FILE_DESCRIPTOR_RECORD

field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
FDR_FIXED_SEGM *	1	180		FILE DESCRIPTOR RECORD FIXED SEGMENT	
1	1	4	B4	Record Sequence Number	1
2	5	5	B1	1st record sub-type code (DECIMAL)	63
3	6	6	B1	Record type code (DECIMAL)	192
4	7	7	B1	2nd record sub-type code (DECIMAL)	18
5	8	8	B1	3rd record sub-type code (DECIMAL)	18
6	9	12	B4	Length of this record	6090
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	28	A12	Control Document Number for this Data File Format	GES$10490$$$
10	29	30	A2	Control Document Revision Number <NN>,where NN=01-99	
11	31	32	A2	File Design Descriptor Revision Letter <XX>, (Initially '$A',then '$B',etc.)	
12	33	44	A12	Software Release Number THFR-CCT-<XXX>, initiall XXX=001,then 002,etc	
13	45	48	I4	File Number	2
14	49	64	A16	File Name LS5$TM<LL>CALBBSQm or LS5$TM<LL>CALBBIL$ <LL> is the level of corrections applied.	
15	65	68	A4	Record Sequence and Location Type Flag	FSEQ
16	69	76	I8	Sequence Number Location	$$$$$$$1
17	77	80	I4	Sequence Number Field Length	$$$4
18	81	84	A4	Record Code and Location Type Flag	FTYP
19	85	92	I8	Record Code Location	$$$$$$$5
20	93	96	I4	Record Code Field Length	$$$4
21	97	100	A4	Record Length and Location Type Flag	FLGT
22	101	108	I8	Record Length Location	$$$$$$$9
23	109	112	I4	Record Length Field Length	$$$4
24	113	113	A1	Flag indicating that data interpretation information is included within the file descriptor record. <X> ,where X=Y OR N ,for YES or NO	
25	114	114	A1	Flag indicating that data interpretation information is included within the file in record(s) other than the descriptor <X> ,where X=Y OR N ,for YES or NO	
26	115	115	A1	Flag indicating that data display information is included within the file descriptor record. <X> ,where X=Y OR N ,for YES or NO	
27	116	116	A1	Flag indicating that data display information is included within the file in record(s) other than the file descriptor. <X> ,where X=Y OR N ,for YES or NO	
FDR_VARIA_SEGM *	117	6090		FILE DESCRIPTOR RECORD VARIABLE SEGMENT	
28	117	120	I4	Mission number	

29	121	124	I4	Path number	
30	125	128	I4	Acquisition year	
31	129	132	I4	Acquisition month	
32	133	136	I4	Acquisition day	
33	137	148	3A4	Acquisition start time	
34	149	160	3A4	Acquisition stop time	
35	161	164	I4	Number of acquired swath	
36	165	168	I4	Number of physical records	
37	169	172	I4	Physical record length	
38	173	174	I2	Blocking factor	
39	175	176	I2	Number of logical records	
40	177	180	I4	Logical record length	
41	181	220	A40	Blanks	
42	221	224	I4	Record relative to first video	
43	225	260	A36	Blanks	
				Locator fields point to the position within the file where various information can be found.	
44	261	276	A16	Scan number field	$$$$$A$$$$21$$2A
45	277	292	A16	Band number field	$$$$$A$$$$25$$2A
46	293	308	A16	Detector number field	$$$$$A$$$$27$$2A
47	309	324	A16	Scan time field	$$$$$A$$$$29$$8A
48	325	340	A16	Rec.seq.num.within phys.rec.	$$$$$A$$$$17$$2A
49	341	356	A16	Scan direction field	$$$$$A$$$$23$$2A
50	357	360	A4	Total of four blanks	
51	361	6090		Blanks	

CALIBRATION_VOLUME
CALIBRATION_FILE
CALIBRATION_RECORD

field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	I4	Record sequence number Number of physical record within the file. Repeated in all logical records.	
2	5	8	I4	Record type code	
3	9	12	I4	Physical record length Length of the record on tape (7*870 = 6090)	6090
4	13	14	I2	Blocking factor	
5	15	16	I2	Length of logic record Set to 870	870
6	17	18	I2	Sequence number (file) Sequence number of the logical record within the calibration file.	
7	19	20	I2	Sequence number (record) Sequence number of the present logical record within the tape record (1-7).	
8	21	22	I2	Scan number	
9	23	24	I2	Scan direction	
10	25	26	I2	Band number	
11	27	28	I2	Detector number	
12	29	36	2I4	Scan start time Same code than scan time in imagery file.	
13	37	38	I2	Calibration lamp status	
14	39	40	I2	Calibration lamps sequence number	
15	41	870	830B1	Calibration values	

3.9 NULL VOLUME DIRECTORY FILE

The logical volume set is terminated with a null volume directory file. The null volume directory contains only one record, namely, the null volume descriptor record whose description and content are contained in the following table :

1. NULL VOLUME DESCRIPTOR RECORD

NULL VOLUME
VOLUME_DIRECTORY_FILE
VOLUME_DESCRIPTOR_RECORD

field or field-group name	start byte	last byte	format	DESCRIPTION AND EXPLANATION	CONTENT
1	1	4	B4	Record Sequence Number	1
2	5	5	B1	1st record sub-type code (Decimal)	192
3	6	6	B1	Record type code (Decimal)	192
4	7	7	B1	2nd record sub-type code (Decimal)	63
5	8	8	B1	3rd record sub-type code (Decimal)	18
6	9	12	B4	Length of this record	360
7	13	14	A2	ASCII/EBCDIC Flag	A$
8	15	16	A2	2 Blanks	$$
9	17	28	A12	Superstructure control document number	CCB-CCT-0002
10	29	30	A2	Superstructure control document revision number <XX> (initially '$C')	
11	31	32	A2	Superstructure record format revision letter <XX> (initially '$A',then '$B',ext...)	
12	33	44	A12	Software release number TMFR-CCT-<XXX> (initially XXX = 001,then 002,ext.)	
13	45	60	A16	identifier of logical volume containing this volume descriptor : <MMSTYDDDPPPRRRAA>	
14	61	76	A16	Physical Volume ID	Blanks
15	77	92	A16	Volume Set ID	Blanks
16	93	94	I2	Number of Physical Volumes in the Set <$N> where N=1,or2,or3.	
17	95	96	I2	Physical Volume Number, Start of Logical Volume	$1
18	97	98	I2	Physical Volume Number, End of Logical Volume <$N> where N=1,or2,or3.	
19	99	100	I2	Physical Volume sequence number (i.e. of current tape) <$N> where N=1,or2,or3.	
20	101	104	I4	First Referenced File Number in this Physical Volume	Blanks
21	105	108	I4	Logical Volume Number within Volume Set	$$$4
22	109	112	I4	Logical Volume Number within Physical Volume	$$$4
23	113	120	A8	Logical Volume Creation Date <YYYYMMDD>	Blanks
24	121	128	A8	Logical Volume Creation Time <HHMMSSXX>	Blanks
25	129	140	A12	Logical Volume Generating Country ITA - FUCINO or SWE - KIRUNA	Blanks
26	141	148	A8	Logical Volume Generating Agency	ESA-EPO
27	149	160	A12	Logical Volume Generating Facility ITA - FUCINO or SWE - KIRUNA	Blanks
28	161	164	I4	Number of Pointer Records in Volume Directory	Blanks
29	165	168	I4	Number of Records in Volume Directory	Blanks
30	169	260	A92	Volume Descriptor Spare Segment	Blanks
31	261	360	A100	Local Use Segment	Blanks

ANNEX 1

STANDARD FORMAT FAMILY OVERVIEW

This chapter has been designed to acquaint the user with the philosophy behind the ESA standard Landsat TM Computer Compatible Tape (CCT) format design, showing its relationship to other implementations of the standard format, and giving an overview of the type of data contained within each record.

A.1 STANDARD FORMAT INTRODUCTION

The standard format used by ESA for Landsat TM data is a member of the standard CCT family of tape formats, as defined by the Landsat Ground Station Operators' Working Group (LGSOWG) Technical Working Group (LTWG), and as maintained by the LGSOWG Change Control Board (CCB).
The standard format family incorporates the concept of a superstructure at four distinct levels, namely, volume, file, record and data field level, which permits the precise structure of the CCT to be defined within the tape itself. A major advantage emanating from this constraint is that CCT's incorporating the superstructure and containing data from the same remote sensing source (for example, Landsat TM), but generated by many different agencies, can be read with identical software. In addition, imagery data from other remote sensing sources, such as Landsat MSS data, airborne MSS data, and Seasat SAR data, when recorded in the standard format, can also be read with the same software.
The specific details of the standard format family of tape formats are defined by Buhler (1979), while the remainder of this section gives an overview of the most important features.

A.2 SUPERSTRUCTURE OVERVIEW

The general superstructure of a product is shown in Figure A.2. Within the standard format family, data files are logically grouped on a tape or set of tapes, and this group is referred to as a logical volume. The individual tapes are the physical volumes. The family is sufficiently general to permit the storage of many logical volumes within one physical volume, or to split one logical volume across several different physical volumes. In addition, volume sets, consisting of more than one logical volume, each of which may span more than one physical volume, are also accommodated within the family.

At the highest level of organisation, a logical volume written in the standard format may be seen to consist of an introductory file (the volume directory, which defines the logical and physical construction of the volume), the set of data files, and finally, a terminating file (the null volume directory). This null volume directory is only present after the last logical volume of a volume set.
Within the volume directory file, the first record is a volume descriptor record. This is followed by one file pointer record, for EACH data file within the logical volume, which is used to define the logical construction of that data file. This is optionally followed by a text record, which serves only as a descriptive record stored in alphanumeric form.
Within each data file, the first record is a file descriptor record containing detailed information on how to interpret the contents of its constituent records. In addition, each file has associated with it a file class, to identify the broad category to which the data belongs.
Finally, within each data record, the first six fields (twelve bytes) are normally used to specify that record's sequence number within the file, some record type coding information, and the length of the record.
It is therefore possible for two agencies to record Landsat TM imagery in records of different lengths, storing, for example, the scan line number in quite different locations. Since the file classes and record type codes are uniquely maintained by the LGSOWG CCB, it is possible to generate software which is driven by these two parameters alone to select the desired information from the records in the data files.

A.3 SUPERSTRUCTURE RECORDS

There are only four superstructure records required to specify any standard family format. They are briefly described in the following four subsections, paying particular attention to the fields which are required to interpret the data files included within the volume. The precise location, format and content of these fields are given in Figure 7, and may represent all the information required by some users to interpret their tapes.
All superstructure records start with the record introductory information, consisting of record sequence number, record type and record length, stored in binary. All other fields are stored in ASCII, and are multiples of two bytes.

A.3.1 VOLUME DESCRIPTOR RECORD

The volume descriptor record contains all the information which applies to the logical volume as a whole, such as data source information, physical volume identification, and the physical relationship of the logical volume to other logical volumes within the tape or tape set. of equal importance, is the specification of the number of file pointer records (and hence, of data files), and the number of text records. The contents of the volume descriptor record are explained in detail in Table A.3.1.

The last file following the last logical volume within a volume set is the null volume directory file, consisting of one record only, the null volume descriptor record. Its purpose is two-fold: firstly, it marks the end of the volume set, and secondly it facilitates the addition of data to a tape which already contains data. In the latter case, the null volume directory file would be converted to a volume directory file by overwriting the null volume descriptor record with a volume descriptor record and appending the appropriate file pointer records.

A.3.2 FILE POINTER RECORD

There is one file pointer record for each of the data files on the tape, and it supplies the number and name of the associated data file, the maximum record length and an indication of the content of the file in terms of the type and format of the data. (The use of file pointer records therefore gives the user sufficient information to skip files, if desired). The contents of the file pointer record are explained in detail in Table A.3.2.

A.3.3 TEXT RECORD

The text record is simply an extra record stored in the volume directory file to provide any type of information in human readable form. ESA-EPO uses the text record to specify the product type and processing performed, the location, date and time of product creation, the specific scene identification and the physical tape identification. It is therefore a convenient means of confirming that the correct CCT is being processed. An example of its contents is provided in Figure 8.

A.3.4 FILE DESCRIPTOR RECORD

The file descriptor record is separated into two segments, a fixed segment and a variable segment. The format of the first segment, as its name implies, is predetermined and it contains the file number and name, and specifies the format and location within each data record of the record introductory information, namely, the sequence number, type code and record length. The contents of the fixed segment of the file descriptor record are explained in detail in Table A.3.4.

The format of the variable segment is unique to each individual file class, but several general rules are usually followed. For example, the number and length of up to three different record types may be specified. "Locators", giving the precise location and format of data considered to be important, are widely used. In addition, for files containing imagery data, valuable information concerning, for example, how pixels are packed within bytes, and the exact location of imagery data within the record, are also specified.

It is these last two components, namely, the field locators and the detailed pixel location specifications, which provide so much of the flexibility for processing similar data products from other sources.

TABLE A.1
LANDSAT TM RECORD TYPE CODES

BYTE 5 OCTAL	BYTE 6 OCTAL	BYTE 7 OCTAL	BYTE 8* OCTAL	DESCRIPTION
300	300	022	022	Volume Descriptor
300	300	077	022	Null Volume Descriptor
333	300	022	022	File Pointer
077	300	022	022	File Descriptor
022	077	022	022	Text Record
022	022	022	011	Scene Header
044	044	022	011	Ancillary (Map Projection)
077	044	022	011	Ancillary (Radiometric Calibration)
111	022	111	044	Interval Header
177	044	111	044	TM Housekeeping Ancillary
366	044	111	044	Ephemeris and Attitude Ancillary
544	044	222	044	Raw Jitter Measurements Ancillary
355	333	022	011	Imagery
022	366	333	011	Trailer

---

* Byte 8 takes the value 011(8) for record constructions defined by the LTWG, or the value 044(8) for record constructions defined by CCRS. The default value for byte 8 is 022(8).

TABLE A.2

STRUCTURE OF A LANDSAT SYSTEM CORRECTED CCT PRODUCT
(QUARTER FRAME BSQ)

		IMAGERY VOLUME DIRECTORY FILE	
		VOL. DES. REC.	360
	=	FILE POINT. REC. LEADER FILE	360
7 TIMES	=	FILE POINT. REC. IMAGERY FILE	360
	=	FILE POINT. REC. TRAILER FILE	360
		TEXT REC.	360
	=	LEADER FILE	
	=	FILE DESCRIPTOR REC.	4320
	=	SCENE HEADER REC.	4320
	=	MAP PROJECTION ANCILLARY REC.	4320
	=	RADIOMETRIC ANCILLARY REC.	4320
	=		
7 TIMES	=	IMAGERY FILE	
	=	FILE DESCRIPTOR REC.	3600
	=	IMAGE REC.	3600
	=		
	=	TRAILER FILE	
	=	FILE DESCRIPTOR REC.	4320
	=	TRAILER REC.	4320
		SUPPLEMENTAL VOLUME DIRECTORY FILE	
		VOL. DES. REC.	360
		FILE POINTER REC. SUPPL. FILE	360
		TEXT REC.	360
		SUPPLEMENTAL FILE	
		FILE DESCRIPTOR REC.	540
		INTERVAL HEADER REC.	1800
one or more		TM HOUSEK. DATA ANCIL. REC.	2880
one or more		EPHEM. AND ATT. ANCIL. REC.	4680
one or more		RAW JITTER MEASUR. ANCIL. REC.	6300
		CALIBRATION VOLUME DESCRIPTOR FILE	
		VOL. DES. REC.	360
		FILE POINTER REC. CAL. FILE	360
		TEXT REC.	360
		CALIBRATION FILE	
		FILE DESCRIPTOR REC.	6090
		CALIBRATION DATA REC.	6090
		NULL VOLUME DESCR. REC.	360

TABLE A.3.1
VOLUME DESCRIPTOR RECORD - DETAILED EXPLANATION

Fields 1 to 6 are binary encoded fields. All other fields are in ASCII. Alphanumeric character strings are left-justified and numeric character strings are right-justified. Any fields not used are filled with ASCII blanks. Numbers which do not fill the field should be padded with leading blanks.

FIELD	EXPLANATION
1	A binary number containing the sequence number of this record within the file.
2	The first record sub-type code for the volume descriptor record is 300(8).
3	The record type code for superstructure records is 300(8).
4	The second record sub-type code for the volume descriptor record is 022(8). For the null volumedescriptor record, it is 077(8).
5	The third record sub-type code for all superstructure records is 022(8).
6	This field contains a binary number giving the length of this record in bytes.
7	The ASCII/EBCDIC flag indicates if the alphanumeric information in the Volume Directory File is in ASCII or EBCDIC. For the Landsat TM format, ASCII only will be used, so this field will contain A$, where $ denotes an ASCII blank (i.e. 040(8)). Unless otherwise specified, $ represents a blank character.
8	Two blanks.
9	12 characters giving the Superstructure Format Control Document identifying number
10	2 characters indicating the revision number or letter of the Superstructure Format Control Document. Coded $C, for the original draft
11	2 characters indicating the revision letter of the Superstructure Record formats. Coded $A for the original draft . This code updates one letter character, alphabetically, each time there is a change to the format of a Superstucture Record (as opposed to a change to the control document which may not have been a change in the actual record format). The 26th revision is coded AA, the 27th AB, and so on.
12	12 characters identifying the software version used to write this Logical Volume.

13 First 16 characters (of 32) written or printed externally on the Physical Volume and used to uniquely reference a particular CCT. Also called the Tape Identifier. This part refers to input data characteristics

M=mission ('L' for Landsat)
N=Mission Number ('4' or '5' for L-D or L-D')
S=Sensor type ('T' for TM)
YYDDD = year and day of acquisition
PPPRRR = Path and Row in WRS
AA = Acquisition Station Identifier

14 Second 16 characters which identify the CCTs. These refer to output CCTs characteristics.
AA = Processing Station Identifier
Q = quadrant number, where quadrant 1 contains the upper right quarter, quadrant 2 contains the upper left quarter, quadrant 3 contains the lower left quarter and quadrant 4 contains the lower right quarter of the full scene.X=0 for a full scene
YYDDDHHMMSS = Year,Day,Hour,Minuts,Seconds when the CCT has been generated.
N = CCT Sequence Number
n = Number of CCTs Generated for current product

15 A second 16 character field for identifying the Volume Set. The volume set identifier is composed of the satellite identification, and sensor description, LANDSAT$TM$$$$$

16 An integer which indicates the total number of Physical Volumes in a Volume Set. A blank field indicates that the information was not available at the time the Logical Volume was recorded.

17 This indicates the sequence number of the Physical Volume within a Volume Set, which contains the 1st record of the Logical Volume. For this format, this will always be 1. (2 characters)

18 This field indicates the sequence number of the last Physical Volume of a Volume Set. It should be coded blank if unknown at the time of recording. If the Logical Volume is contained on one Physical Volume, this field will have the same value as field 17. (2 characters)

19 This is the sequence number within the Volume Set of the Physical Volume that contains this Volume Directory File. If a Logical Volume is contained on one Physical Volume, then this value is the same as that for field 17. The value in this field must lie within the values for fields 17 and 18, inclusively. (e.g., if field 17 has a 1 and field 18 has a 3, then the value in field 19 can be 1,2 or 3, only). (2 characters)

20 This field gives the file number within the Logical Volume which follows this Volume Directory. If this is not the first Volume Directory of a Logical Volume, then this value may be greater than one. Volume Directory Files are not included in the file sequence number count. (4 characters)

21 This indicates the sequence number of the present Logical Volume within a Volume Set. The Null Volume directory is included in this count. The first logical volume is denoted as 1.

22 This is the sequence number of the present Logical Volume within a Physical Volume.

23 8 characters for the date the Logical Volume was recorded. The code is of the form: <YYYYMMDD>, where YYYY is year, MM is month, and DD is day (e.g. 19830622 is June 22, 1983)

24 8 characters for the time when the Logical Volume was recorded. The code is of the form: <HHMMSSXX>, where HH is hours, MM is minutes, SS is seconds, and XX is hundredths of seconds

25 12 characters for the name of the country generating this Logical Volume

26 8 characters for the laboratory or centre generating this Logical Volume.

27 12 characters identifying the computer facility on which the Logical Volume was recorded

28 The number of File Pointer Records in this Directory File. This gives the number of data files in the Logical Volume, (4 characters)

29 Total number of records in this Volume Directory. This will be the number of File Pointer Records plus one (for this record) plus the number of Text Records. (4 characters)

30 92 bytes reserved by LGSOWG CCB for future revisions of this record format.

31 100 bytes available for local use. This format does not use this field, so it is filled with blanks.

TABLE A.3.2
FILE POINTER RECORD - DETAILED EXPLANATION

Fields 1 to 6 are binary encoded fields. All other fields are in ASCII. Alphanumeric character strings are left-justified and numeric character strings are right-justified. Any fields not used are filled with blanks. Numbers which do not fill the field should be padded with leading blanks. The File Pointer Record occupies 360 bytes.

FIELD	EXPLANATION
1	A binary number containing the sequence number of this record within the file. This number will be between 2 and the number specified in field 29 of the Volume Descriptor Record.
2	The first record sub-type code for file pointer records is 333(8).
3	The record type code for superstructure records is 300(8).
4	The second record sub-type code for file pointer records is 022(8).
5	The third record sub-type code for all superstructure records is 022(8).
6	This field contains a binary number giving the length of this record in bytes. This value is 360 for this record.
7	The ASCII/EBCDIC flag indicates if the alphanumeric information in the referenced file is in ASCII or EBCDIC. For the AVHRR format, ASCII only will be used, so this field will contain A$.
8	Two blanks.
9	Sequence number within the Logical Volume of the file referenced by this pointer. This is also the sequence number of the File Pointer Record within the Volume Directory. The first file following the first Volume Directory (2nd file of the Logical Volume) is file number 1. (4 characters)
10	A 16 character name which is the unique identification provided when the volume directory is created in order to specify the file referenced by this pointer.
11	This is a 28 character description of the class to which the referenced file belongs. The class of a file is based on the nature of its content.
12	The 4-byte code for the class described in field 11.
13	This 28-character field indicates the data type

contained in the referenced file.

14 The 4-byte code for the data type described in field 13.

15 This 8 character field indicates the number of records in the referenced file. If this number is not known at the creation time, then this field is blank.

16 8 characters for the length, in bytes, of the File Descriptor Record in the referenced file. A blank field indicates that the information was not available at the time the Logical Volume was recorded.

17 8 character field for the length, in bytes, of the longest record in the referenced file other than the File Descriptor Record.

18 12 characters for the record length type. For this format, fixed length records are used, so this field will contain 'FIXED LENGTH'. The record length is given in field 17.

19 4-byte code for the record length type in field 18. For this format, this is 'FIXD'.

20 2 characters for the Physical Volume sequence number which contains the first record of the referenced file. May be left blank if information unknown at time of recording.

21 2 characters for the Physical Volume sequence number which contains the last record of the referenced file. May be left blank if information unknown at time of recording.

22 When a portion of the referenced file is on the PREVIOUS Physical Volume, this 8 character number is the record number of the first record of the referenced file to be recorded on THIS Physical Volume. In all other conditions, this number is 1. This, and the following field, are the only fields in a File Pointer Record to be changed on a repeated Volume Directory and are only changed in the File Pointer Record that refers to the split file.

23 When a portion of the referenced file is on the NEXT physical volume, this 8 character number is the record number of the last record of the referenced file to be recorded on THIS phyiscal volume.

24 108 bytes reserved for subsequent revisions. This is reserved by the LGSOWG-CCB.

25 100 bytes available for local use. This format does not use this field.

TABLE A.3.3
TEXT RECORD - IMAGERY VOLUME - EXPLANATION

FIELD	EXPLANATION
1-6	The first six fields are defined by the LGSOWG standard format.
7	The ASCII/EBCDIC flag indicates if the alphanumeric data of this record is ASCII or EBCDIC.
8	This field contains two blanks unless the information of this record is continued on a following record, in which case, the field is coded C$.
11	The scene identification is made up in the following way: <MDDDDHHMMSS> where: DDDD=Day number since launch HHMMSS=Hours , minutes and seconds GMT at which the centre point was imaged.
20	HDT Generation date, where YY = Last two digits of year (01-99) DDD = Day of year (001-366)

TABLE A.3.4
FILE DESCRIPTOR RECORD - DETAILED EXPLANATION

Fields 1 to 6 are binary encoded fields. All other fields are in ASCII. Alphanumeric character strings are left-justified and numeric character strings are right-justified. Any fields not used are filled with blanks. Numbers which do not fill the field are padded with leading blanks.

FIELD	EXPLANATION
1	A binary number containing the record number of this record within the file. For the File Descriptor Record, this number is always 1.
2	The first record sub-type code for file descriptor records is 077(8).
3	The record type code for superstructure records is 300(8).
4	The second record sub-type code for file descriptor records is 022(8).
5	TThe third record sub-type code for all superstructure records is 022(8).
6	This field contains a binary number giving the length of this record in bytes.
7	The ASCII/EBCDIC flag indicates if the alphanumeric information in the Referenced File is in ASCII or EBCDIC. For the Landsat TM format, ASCII only will be used, so this field will contain A$.
8	Two blanks.
9	12 characters containing the number for the document that controls this file format.
10	2-bytes giving the revision number of the control document defining the current file format.
11	2-bytes giving the revision letter of the file format (as opposed to revisions which affect the control document without affecting the file format).
12	12 characters identifying the software version used to write this file.
13	4-byte sequence number of this file within the Logical Volume, excluding the volume directory.
14	This is the unique 16 character identification of the present file as stated in field 10 of the File Pointer Record of the Volume Directory File.

15 This 4-byte field indicates if the other records in the file have sequence numbers.

16 These eight bytes give the location of the start of the sequence number field. They give the record byte number of the first byte of the field.

17 Four bytes indicating the length, in bytes, of the record sequence number field.

18 4-byte flag to indicate if the other records in the file have a record type code, and if the location of the code is fixed or variable.

19 These eight bytes give the location of the start of the record type code field. They give the record byte number of the first byte of the field.

20 Four bytes, indicating the length, in bytes, of the record type code field

21 4-byte flag to indicate if the other records in the file contain their record lengths.

22 These eight bytes give the location of the start of the record length field. They give the record byte number of the first byte of the field.

23 Four bytes, indicating the length, in bytes, of the record length field.

28 64 bytes for future expansion. Reserved by the LGSOWG-CCB.

29 File descriptor variable segment (see Tables 3.2.1.3, 3.3.1.2 and 3.4.1.2).

Enhanced Thematic Mapper Plus (Landsat 7)

Brief Record | Distribution | Attributes | Coverage | Personnel | Full Record | Update Record

brief distribution attributes coverage personnel full update

Summary

2002-01-07

Abstract:
This data set is a raster file containing global information for bands 1 through 8 for Landsat 7 Enhanced Thematic Mapper Plus (Landsat 7 ETM+).

Purpose:
The mission of the Landsat-7 satellite is to provide a vehicle for continuing the flow of global change information to users worldwide. The Landsat-7 satellite fulfills its mission by providing repetitive, synoptic coverage of continental surfaces and by collecting data in spectral bands that include the visible, near-infrared, shortwave, and thermal infrared portions of the electromagnetic spectrum. Landsat-7 mission objectives include:

1) Maintaining Landsat data continuity by providing data that are consistent in terms of data acquisition, geometry, spatial resolution, calibration, coverage characteristics, and spectral characteristics with previous Landsat data.

2) Generating and periodically refreshing a global archive of substantially cloud-free, Sun-lit, land-mass imagery.

3) Continuing to make remote sensing satellite data available to domestic and international users and expanding the use of such data for global change research in both the Government and private commercial sectors.

4) Promoting interdisciplinary research via synergism with other EOS observations, specifically, orbiting in tandem with the EOS Terra satellite for near coincident observations.

Supplemental_Information:
The Landsat-7 system is another step in the development and application of remotely sensed satellite data for use in managing the Earth's land resources. As with earlier Landsat systems, the Landsat-7 platform, along with its enhanced thematic mapping sensor, provides for new capabilities in the remote sensing of Earth's land surface. Landsat-7 data are collected from a nominal altitude of 705 kilometers in a near-polar, near-circular, Sun-synchronous orbit at an inclination of 98.2 degrees, imaging the same 183-km swath of Earth's surface every 16 days. Some of the browse images you encounter may appear black or empty. These are engineering data known as Full Aperture Calibrator (FAC) data. The FAC is a white painted panel that is deployed in front of the ETM+ aperture and diffusely reflects solar radiation into the full aperture of the instrument. The FAC scenes are typically gathered on a monthly basis and constitute roughly 5 to 7 scenes for each FAC collected.

Eventually these engineering data will be gleaned out of the database. Depending on the time of year, the solar azimuth angle with respect to the volocity vector of the ETM+ sensor,

varies from 23 degrees to 37 degrees. This is the only area where FAC data will be collected. Further, in-depth information can be found at the following site: http://landsat.gsfc.nasa.gov/

Landsat-7 Level-0 and Level-1 Data Sets Document
http://eosims.cr.usgs.gov:5725/DATASET_DOCS/landsat7_dataset.html

National Land Archive Production System (NLAPS) Systematic Format Description Document http://edc.usgs.gov/customer.html
Level 1 Product Output Files Data Format Control Book
http://edc.usgs.gov/17dhf/L7MMO/document.htm

Data Set Credit:
The Landsat Program, as defined by Congress in 1992 and amended by Presidential Decision Directive/NSTC-3 in May 1994, is managed cooperatively by the National Aeronautics and Space Administration (NASA), and the USGS. Responsibility for construction of the spacecraft and instrument lies with NASA. The Landsat Program is part of NASA's Earth Observing System global change initiative administered by NASA's Earth Science Enterprise. Data processing, archiving, and distribution are performed by the USGS. The primary ground station, the data handling facility and archive are located at the USGS EROS Data Center in Sioux Falls, SD. NASA managed flight operations from the control center at the Goddard Space Flight Center until October 1, 2000, at which time responsibility for flight operations transfered to the USGS. The ground system is able to distribute raw ETM+ data within 24 hours of its reception at the EROS Data Center. These functions are executed in coordination with the EDC Distributed Active Archive Center (EDC DAAC) of NASA's Earth Observing System Data and Information System.

Data Set Citation

Dataset_Creator: U.S. Geological Survey
Dataset_Title: Enhanced Thematic Mapper Plus (Landsat 7)
Dataset_Release_Place: Sioux Falls, South Dakota, USA
Dataset_Publisher: U.S. Geological Survey
Data_Presentation_Form: Remote-sensing image
Online_Resource: http://edc.usgs.gov

Temporal Coverage

Start Date: 1999-04-15

Geographic Coverage

Southernmost Latitude: 82.0S
Westernmost Longitude: 180.0W
Northernmost Latitude: 82.0N
Easternmost Longitude: 180.0E

Location Keywords

AFRICA
AUSTRALIA
LAND SURFACE
GLOBAL

EUROPE

GREENLAND

NORTH AMERICA

SOUTH AMERICA

ANTARCTICA

ASIA

Parameters

EARTH SCIENCE > LAND SURFACE > LAND USE/LAND COVER > LAND USE CLASSES

EARTH SCIENCE > RADIANCE OR IMAGERY > VISIBLE WAVELENGTHS > VISIBLE IMAGERY

EARTH SCIENCE > RADIANCE OR IMAGERY > INFRARED WAVELENGTHS > BRIGHTNESS TEMPERATURE

EARTH SCIENCE > LAND SURFACE > LANDSCAPE > LANDSCAPE PATTERN

EARTH SCIENCE > LAND SURFACE > SURFACE RADIATIVE PROPERTIES > REFLECTANCE

EARTH SCIENCE > LAND SURFACE > TOPOGRAPHY > LANDFORMS

EARTH SCIENCE > RADIANCE OR IMAGERY > SENSOR CHARACTERISTICS > ULTRAVIOLET SENSOR TEMPERATURE

EARTH SCIENCE > RADIANCE OR IMAGERY > INFRARED WAVELENGTHS > INFRARED IMAGERY

Source

LANDSAT-7

Sensor

ETM+ > Enhanced Thematic Mapper Plus

Quality

```
Attribute_Accuracy:
  Attribute_Accuracy_Report:
A panchromatic band 8 was added with a resolution of 15 meters. Band 6
now has high gain and low gain bands. Three on-board calibrators (two
solar, one internal) provide an absolute accuracy of 5 percent>
excluding band 6.

Logical_Consistency_Report:
Landsat-7 data are collected from a nominal altitude of 705
kilometers in a near-polar, near-circular, Sun-synchronous orbit at an
inclination of 98.2 degrees, imaging the same 183-km swath of the
Earth's surface every 16 days. The pixels representing the bands for
the image are in the data set only once.

Positional_Accuracy:
  Horizontal_Positional_Accuracy:
     Horizontal_Positional_Accuracy_Report:
The Landsat ETM+ sensor is a nadir-viewing, eight-band, multispectral
scanning radiometer that detects spectrally filtered radiation from
several portions of the electromagnetic spectrum while orbiting Earth
from an altitude of 705 kilometers. Nominal ground sample distances or
pixel sizes include 30 meters each for the six visible, near-infrared,
```

and shortwave infrared bands, 60 meters for the thermal infrared band, and 15 meters for the panchromatic band. The ETM+ sensor is designed to produce approximately 3.8 gigabits of data for each Landsat scene and operates from a 3-axis, stabilized satellite platform. Energy reflected from the Earth's surface passes through several ETM+ subsystems before being collected by the solid-state detectors at the focal plane. Landsat ETM+ Wavelength (micrometers) Band 1 0.45-0.52, Band 2 0.53-0.61, Band 3 0.63-0.69, Band 4 0.78-0.90, Band 5 1.55-1.75, Band 6 10.40-12.50, Band 7 2.09-2.35, and Band 8 .52-.90.

Process_Description:
Data collected by the ETM+ sensor flown aboard the Landsat-7 satellite are in a raw format, meaning that radiometric and geometric corrections have not yet been applied to the data. Data collected in the raw format are level-0 data and equate to a Landsat-7 level-0R product. When a Landsat-7 level-0R product is radiometrically corrected, it is referred to as a level-1R product. Radiometric correction is performed either by using gains computed on the fly by the internal calibrator or by using gains available in the calibration parameter file. When a Landsat-7 level-0R product is both radiometrically and geometrically (systematically) corrected, it is referred to as a level-1G product. Correction algorithms model the spacecraft and the sensor, using data generated by onboard computers during imaging events. A level-1G product is a geometrically rectified product that is free from distortions related to the satellite platform, the sensor, and global Earth characteristics. Distortions due to Earth's terrain are still present.

Access Constraints

There are no restrictions to this data set.

Use Constraints

There are no restrictions as to the use of data sold by the U.S. Geological Survey (USGS). We ask that the Earth Resources Observation Systems (EROS) Data Center (EDC) be identified as the source if data are used in a publication. The Enhanced Thematic Mapper Plus (ETM+) systematic data are distributed to all customers. Precision and terrain corrected products are limited to approved research users.

Discipline

EARTH SCIENCE

Entry ID

LANDSAT_ETM_PLUS

Data Set Progress

IN WORK

Originating Center

USGS/EROS

Data Center

Data Center Name: USGS/EROS > Earth Resources Observation Systems Data Center, U.S. Geological Survey
Data Center URL: http://edc.usgs.gov/
Name: EROS DATA CENTER
Phone: 605-594-6151
Fax: 605-594-6589
Email: custserv@usgs.gov
Address:

Customer Services
U.S. Geological Survey
EROS Data Center
47914 252nd Street
Sioux Falls, SD 57198-0001
USA

Distribution

Distribution_Media: On-line (FTP)
Fees: $600 U.S. Dollars

Distribution_Media: 8mm Tape
Distribution_Format: HDF
Fees: $600 USD for Level 1G

Distribution_Media: 8mm Tape
Distribution_Format: HDF
Fees: $475 USD for Level 0R

Distribution_Media: CD-ROM
Distribution_Format: HDF
Fees: $600 USD for Level 1G

Distribution_Media: CD-ROM
Distribution_Format: HDF
Fees: $475 USD for Level 0R

Personnel

Name: INFORMATION SCIENTIST EROS DATA CENTER
Role: DIF AUTHOR
Phone: 605-594-6594
Fax: 605-594-6953
Email: meta@usgs.gov
Address:

Information Services Department
EROS Data Center
U.S. Geological Survey
Sioux Falls, SD 57198-0001

Related URL

URL: http://earthexplorer.usgs.gov
Description: Dataset searching and ordering capabilities are available through EarthExplorer at the above URL.

Reference

Creation and Review Dates

DIF Creation Date: 1999-09-10
Future DIF Review Date: 2002-01-01

Responsible NASA Official: Lola Olsen, olsen@gcmd.nasa.gov
Contact GCMD User Support for assistance.
View GCMD's privacy statement