Landsat TM/ETM+ CEOS/ESA Products

Format Specification

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Part

1

Introduction

Chapter 1.1 Introduction

1.1.1 Purpose

This document describes the standards used by ESA for the distribution of the TM and ETM+ (Thematic Mapper and Enhanced Thematic Mapper) optical sensor products. It provides also technical details of the family format concept. This is followed by a specification of the file classes which are commonly used, and an in-depth review of the organizational features of the file classes which are used for imagery, supplemental and calibration data.

The document deals with the format of raw and system-corrected Landsat products as provided on Standard Magnetic Tape and CD-ROM supports. The recommendations of the LTWG have been followed in detail in the construction of the ESA products format.

The data organisation is Band Sequential (BSQ) with a leader file containing scene introductory information, such as processing parameters, sensor and mission definition, geographic referencing data, radiometric transformation tables etc followed by the video data for ALL scan lines of each spectral band. The video data are grouped together in one imagery data file and then followed by a trailer file, which contains scene statistics for the associated imagery data.

1.1.2 Document Overview

- **Part 1:** The current part, which introduces the document and defines the logical volume organization.
- **Part 2:** Overview of the format, presenting the content of all the logical volumes.
- **Part 3:** Description of the Imagery Logical Volume, with a table for each record of each file.
- **Part 4:** Description of the Supplemental Logical Volume, with a table for each record of each file.
- **Part 5:** Description of the Calibration Logical Volume, with a table for each record of each file.
- **Part 6:** Description of the Null Logical Volume, with a table for each record of each file.

1.1.3 Document History

This document was initially written in Word format (up to version 2.6 - June 13th, 2001) and is now a PDF document generated from a set of source files, which are XML files for the text parts, XML Schemas for the structure definition tables and image files for illustrations and figures. An additional XSL file defines the stylesheet used for the PDF generation.

1.1.4 Reference Documents

This section describes the related documents and applied conventions to be considered within the present document.

- **CCB-CCT-0002 D:** LGSOWG CCT Format CCB Document: The standard CCT family of tape formats - August 28th, 1979.

1.1.5 Abbreviations and Acronyms

This section controls the definition of all abbreviations and acronyms used within this document. A special attention has been paid to inherit abbreviations, acronyms and their definitions from international standards as ISO, ANSI and ECSS.

- **ASCII:** American Standard Code for Information Interchange
- **ANSI:** American National Standards Institute
- **BSQ:** Band Sequential (format)
- **CC:** Cubic Convolution
- **CCB:** Change Control Board
- **CCT:** Computer Compatible Tape

- **CD-ROM:** Compact Disc Read-Only Memory
- **CEOS:** Committee on Earth Observation Satellites
- **CPF:** Calibration Parameter File
- **DEF:** Definitive (used for ephemeris)
- **DTM:** Digital Terrain Model
- **EBCDIC:** Extended Binary Coded Decimal Interchange Code
- **ECSS:** European Cooperation for Space Standardization
- **ESA:** European Space Agency
- **ETM+:** Enhanced Thematic Mapper Plus
- **GEOREF:** Map-oriented Level 1 System Corrected product
- **IAS:** Image Assessment System
- **IEEE:** Institute of Electrical and Electronics Engineers
- **ISO:** International Organization for Standardization
- **LGSOWG:** Landsat Ground Station Operators' Working Group
- **LTWG:** Landsat Technical Working Group
- **NN:** Nearest Neighbour
- **PCD:** Payload Correction Data
- **PDF:** Portable Document Format (from Adobe)
- **RADCOR:** Level 1 Radiometrically Corrected product
- **SOM:** Space Oblique Mercator
- **SYSCOR:** Path-oriented Level 1 System Corrected product
- **TM:** Thematic Mapper
- **UTM:** Universal Transverse Mercator
- **VDF:** Volume Directory File
- **WGS84:** World Geodetic System 1984
- **WRS:** World Reference System
- **XML:** Extensible Markup Language
- **XSL:** Extensible Stylesheet Language

1.1.6 Definitions

This section controls the definition of all common terms used within this document. A special attention has been paid to inherit definitions from international standards as ISO, ANSI and ECSS.

- **Level 0 Reformatted (L0R, RAW):** The Level 0R product is reformatted, raw data. Reformatting includes shifting pixels by integer amounts to account for the alternating forward-reverse scanning pattern of the ETM+ sensor, the odd-even detector arrangement within each band and the detector offsets inherent to the focal plan array engineering design.

  Pixels are neither resampled nor geometrically corrected or registered, i.e. the pixels are NOT aligned per scan line. Any radiometric artifacts such as impulse noise, coherent noise, memory effects, etc. would still be in any L0R image. This product is for users able to do all the processing themselves.
- **Level 1 Radiometrically Corrected (L1R, RADCOR):** The Level 1R product is a radiometrically corrected L0R product, which corrects detector artifacts such as coherent noise, improves cosmetic artifacts such as banding, striping, and dropped lines or pixels, and is calibrated to radiance units, i.e. color corrected, as integer values. Radiometric corrections are not reversible. Pixels are neither resampled

nor geometrically corrected or registered, i.e. the pixels are NOT aligned per scan line. This product also requires extensive processing by the user.

- **Level 1 System Corrected (L1G):** The Level 1G product is radiometrically and geometrically corrected (systematic) to the user-specified parameters including output map projection, image orientation and resampling algorithm. The correction algorithms model the spacecraft and sensor using data generated by onboard computers during imaging. Sensor, focal plane, and detector alignment information provided by the Image Assessment System (IAS) in the Calibration Parameter File (CPF) is also used to improve the overall geometric fidelity.

  The resulting product is free from distortions related to the sensor (e.g. jitter, view angle effect), satellite (e.g. attitude deviations from nominal), and Earth (e.g. rotation, curvature). Residual error in the systematic L1G product is less than 250 meters for Landsat 7 (more for other Landsat missions) in flat areas at sea level. The systematic L1G correction process does not employ ground control or relief models to attain absolute geodetic accuracy.

  The Level 1G product should be considered the standard product for most users. System Corrected images can be produced with 2 different orientations: path-oriented (SYSCOR), that displays on the same rows the satellite acquisition scan lines, or map-oriented (GEOREF) with north-up display. No atmospheric corrections are applied to the images.

- **Nearest Neighbour resampling:** The radiometric value of the output pixel is set equal to the value of the nearest input pixel in the original geometry. This algorithm preserves to the maximum the original radiance values.

- **Cubic Convolution resampling:** The radiometric value of the output pixel is interpolated using the values of its 16 nearest neighbours in the original geometry. This algorithm produces a better looking image but changes the original radiance values.

- **WRS Frame:** The standard worldwide reference system as defined for Landsat 4 and 5 was preserved for Landsat 7. The WRS indexes orbits (paths) and scene centers (rows) into a global grid system (daytime and night time) comprising 233 paths by 248 rows. The term row refers to the latitudinal center line across a frame of imagery along any given path. As the spacecraft moves along a path, the sensor scans the terrain below. During ground processing, the continuous data stream or subinterval is framed into individual scenes each 23.92 seconds of spacecraft to create 248 rows per complete orbit. The rows have been assigned in such a way the row 60 coincides with the Equator (descending node). Row 1 of each path starts at 80°47'N and the numbering increases southward to latitude 81°51'S (row 122). Then, beginning with row 123, the row numbers ascend northward, cross the Equator (row 184) and continue to latitude 81°51'N (row 246). Row 248 is located at latitude 81°22'N, whereupon the next path begins. The Landsat satellites are not placed in a true polar orbit but rather a near polar orbit which means the path/row numbers do not coincide with latitudes 90° north and south.

Chapter 1.2 Structure description rules

In this document, the tables describing the records and their fields are using a set of attributes such as id, type, encoding, length and occurrences. These attributes are field-level based and are repeated on each row of the table, since one row is dedicated to one field.

The table sample below shows how fields are described. The columns are defined in the next sections.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Pixel number. This is the number of pixels per image line.
2	5	6	dateTime (A)	Acquisition date. This is the date when the scene was acquired by the satellite. Format is 'YYMMDD' where : 'YY' is the year, 'MM' the month and 'DD' the day of acquisition.
satellite_identifier				
3	11	8	string (A)	Satellite name. This is a part of the satellite identifer (e.g. 'LANDSAT ').
3	19	1	short (A)	Satellite number (e.g. '7').
4	20	6 x3500	unsignedByte (B)	Pixels. This is the array of pixels reprensenting a line. The number of pixel occurrences is defined by field 1.

1.2.1 Id

All fields are identified using incremental numbers, starting from 1. When a field is split into several sub-fields, they all have the same identifier. For instance in the above table, the Id is 3 for both the "Satellite name" and "Satellite number", which are parts of the "Satellite identifier" field.

1.2.2 Offset (Byte)

A field can be directly accessed using its offset. This column gives the offset of the first byte of the field, starting from 1. As a general rule, the offset of a field is the one of the previous field plus its length. However some unused segments can be omitted in the description, introducing in this case some gaps.

Note: The offset is relative to the record, not from the beginning of the file. The size of each previous record of the file must be added prior to call any seek() function requiring absolute offset.

1.2.3 Length

The length of a field is given in bytes and for one occurrence. In case of multiple occurrences the number is added to the column (see next section).

1.2.4 Occurrence

The default number of occurrences for a field is 1, this information does not appear in the table. However, several fields can have multiple occurrences such as Pixels in the sample table above (field 4 with 3500 occurrences). In this case the number of occurrences is added to the Length column ("x3500" in the sample).

1.2.5 Type

Each field as a type which can be one of the following:

- byte

- unsignedByte
- short
- unsignedShort
- int
- unsignedInt
- long
- unsignedLong
- float
- double
- string
- dateTime

1.2.6 Encoding

In addition to the length and type, the knowledge of the encoding method is necessary to extract correctly any field value. This information is given, next to the type, as a code between parenthesis and can be one of the following.

- **Alphanumeric (A):** The field is in ASCII or EBCDIC. The distinction is usually made with a dedicated field at the beginning of each record (ASCII/EBCDIC flag). In addition a specific pattern can be given in the description to allow extracting the value in a particular format (e.g. "YYYYMMDD" for a date).
- **Binary (B):** The field is encoded in binary. Float and double numbers are encoded using the IEEE standard. Byte, short, int and long are encoded with the most significant bit first and can be signed or unsigned.

Part

2

Format Overview

Chapter 2.1 Logical Volume Organization

2.1.1 Definition

Landsat data products are organised into logical volumes, which can span one or more tapes or CDs (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 (see next chapter) conveniently handle multiple physical volumes, with data split across physical volumes either between files or between records within files.

Any product can be accommodated in one exabyte or one CD-ROM, except the map-oriented product that may require two CDs.

The raw and system-corrected Landsat data set, as recommended by the LTWG, consists of three logical volumes, namely, the imagery logical volume, the supplemental logical volume and the null logical volume. These volumes may be considered quite independently from each other, from both the product definition and data processing points of view, since each can exist independently as a valid data set. ESA has added another logical volume, namely, the calibration logical volume, after the supplemental logical volume and before the null volume.

2.1.2 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.

2.1.3 Supplemental Logical Volume

The supplemental logical volume is defined in general terms to contain station-related processing data, such as annotation, ephemeris, 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 telemtry 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.

2.1.4 Calibration Logical Volume

The calibration logical volume contains calibration data acquired from the Landsat satellites within the Landsat data stream.

2.1.5 Null Logical Volume

The role of the null logical volume is to end the set of volumes.

2.1.6 Structure summary

Each volume is divided into one or more files, at least a volume contains the Volume Directory File, which describes the struture of the volume. The files are structured into a set of records and a record contains fields, which are sometimes split into sub-fields. The files are detailed in the next part. For each file type a class code is defined (up to 4 characters).

The struture of the volumes is the following :

- Imagery Logical Volume
    - Volume Directory File (VDF)
    - Leader File (LEAD)

    - Imagery File (IMGY)
    - Trailer File (TRAI)
- Supplemental Logical Volume
    - Volume Directory File (VDF)
    - Supplemental File (SUPP)
- Calibration Logical Volume
    - Volume Directory File (VDF)
    - Calibration File (CALB)
- Null Logical Volume
    - Volume Directory File (VDF)

Note: All volumes have a Volume Directory File and this file has always the same structure definition. See "Standard Family" chapter.

However, when the volume set spans multiple physical volumes, specifically when one constituent logical volume spans more than one tape or CD-ROM, the volume directory file for that logical volume is repeated at the start of the new tape or CD-ROM. 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.

The Leader, Imagery, and Trailer files are repeated for each band of the product. A Landsat 7 product with all bands will have, therefore, 9 times these 3 files in the Imagery Logical Volume. In addition, the Supplemental Logical Volume will have two different supplemental files.

Here is an example of Landsat 7 product's files:

- Imagery Logical Volume
    - Volume Directory File
    - Leader File (VNIR/SWIR 1)
    - Imagery File (VNIR/SWIR 1)
    - Trailer File (VNIR/SWIR 1)
    - Leader File (VNIR/SWIR 2)
    - Imagery File (VNIR/SWIR 2)
    - Trailer File (VNIR/SWIR 2)
    - Leader File (VNIR/SWIR 3)
    - Imagery File (VNIR/SWIR 3)
    - Trailer File (VNIR/SWIR 3)
    - Leader File (VNIR/SWIR 4)
    - Imagery File (VNIR/SWIR 4)
    - Trailer File (VNIR/SWIR 4)
    - Leader File (VNIR/SWIR 5)
    - Imagery File (VNIR/SWIR 5)
    - Trailer File (VNIR/SWIR 5)
    - Leader File (VNIR/SWIR 7)
    - Imagery File (VNIR/SWIR 7)
    - Trailer File (VNIR/SWIR 7)

    - Leader File (Thermal 6L)
    - Imagery File (Thermal 6L)
    - Trailer File (Thermal 6L)
    - Leader File (Thermal 6H)
    - Imagery File (Thermal 6H)
    - Trailer File (Thermal 6H)
    - Leader File (PAN)
    - Imagery File (PAN)
    - Trailer File (PAN)
- Supplemental Logical Volume
    - Volume Directory File
    - Supplemental File (Format 1)
    - Supplemental File (Format 2)
- Calibration Logical Volume
    - Volume Directory File
    - Calibration File (VNIR/SWIR)
    - Calibration File (Thermal)
    - Calibration File (PAN)
- Null Logical Volume
    - Volume Directory File

Chapter 2.2 Standard Family

This chapter has been designed to acquaint the user with the philosophy behind the standard Landsat Tape 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.

Note: This format was first designed for tapes but is still applicable to the products delivered by CD-ROMs.

2.2.1 Introduction

The standard format used by ESA for Landsat data is a member of the standard family of tape formats, as defined by the Landsat Ground Station Operators' Working Group (LGSOWG) and Technical Working Group (LTWG), and as maintained by the LGSOWG Change Control Board (CCB). See also document CCB-CCT-0002 D (Part 1 - Reference Documents).

The standard format family incorporates the concept of a superstructure at four distinct levels, namely :

- Volume
- File
- Record
- Field

These levels enable the precise structure of the supporting medium to be defined within the tape itself. A major advantage emanating from this constraint is that tapes 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.

2.2.2 Superstructure Overview

The general superstructure concepts are based on the assumption that 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 records are the following:

- Volume Directory File
    - Volume Descriptor Record
    - File Pointer Records
    - Text Record

The first record is a volume descriptor record. This is followed by one file pointer record for each data file within the logical volume. This pointer record is used to define the logical construction of that data file. Then they are 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:

- Any Data File
    - File Descriptor Record
    - Other Records

In addition, each file is associated to 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 the 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 differing 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.

2.2.3 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 supplied 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 codes and record length, stored in binary. All other fields are stored in ASCII.

The table below describes the first 6 fields composing the record introductory information. These fields are present in all records. The total length of this introductory information is 12 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).

Depending on the record types the fields contain different values, described in the following figure.

Data Type	First Sub-type Codes	Record type Codes	Second Sub-type Codes	Third Sub-type Codes
Volume Directory File, Volume Descriptor	$(300)_8$	$(300)_8$	$(022)_8$	$(022)_8$
Null Volume Descriptor	$(300)_8$	$(300)_8$	$(077)_8$	$(022)_8$
Volume Directory File, File Pointer	$(333)_8$	$(300)_8$	$(022)_8$	$(022)_8$
Volume Directory File, Text	$(022)_8$	$(077)_8$	$(022)_8$	$(022)_8$
File Descriptor	$(077)_8$	$(300)_8$	$(022)_8$	$(022)_8$
Leader file, Scene Header	$(022)_8$	$(022)_8$	$(022)_8$	$(011)_8$
Leader file, Ancillary (Map Projection)	$(044)_8$	$(044)_8$	$(022)_8$	$(011)_8$
Leader file, Ancillary (Radiometric Calibration)	$(077)_8$	$(044)_8$	$(022)_8$	$(011)_8$
Imagery file, Imagery	$(355)_8$	$(355)_8$	$(333)_8$	$(011)_8$
Trailer file, Trailer	$(022)_8$	$(366)_8$	$(022)_8$	$(011)_8$
Supplemental file, Interval Header	$(111)_8$	$(022)_8$	$(111)_8$	$(044)_8$
Supplemental file, TM Housekeeping Ancillary	$(177)_8$	$(044)_8$	$(111)_8$	$(044)_8$
Supplemental file, Ephemeris and Attitude	$(370)_8$	$(044)_8$	$(111)_8$	$(044)_8$
Supplemental file, Raw Jitter Ancillary	$(344)_8$	$(044)_8$	$(222)_8$	$(044)_8$
Calibration file, Calibration	$(300)_8$	$(300)_8$	$(300)_8$	$(300)_8$
Supplemental file, Supplemental	$(176)_8$	$(177)_8$	$(22)_8$	$(55)_8$

Record type codes

Volume Descriptor Record

The volume descriptor record contains all the information that 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 the table below.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	12	string (A)	Superstructure format control document identifier.
10	29	2	string (A)	Superstructure control document revision number. It indicates the revision number or letter of the Superstrucure Format Control Document. Coded $C, for the original draft.
11	31	2	string (A)	Superstucture record format revision letter. It indicates the revision letter of the Superstrucure records 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 Superstructure 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	33	12	string (A)	Superstructure software release number. It identifies the software revision used to write this logical volume.
Logical volume id				
13	45	3	string (A)	'MNS': Mission, Number and Sensor type (e.g. 'L7E' for Landsat 7 ETM). Part of the logical volume identifier.
13	48	2	short (A)	'YY': Year of acquisition
13	50	3	int (A)	'DDD': Day of acquisition
13	53	3	int (A)	'PPP': Path in WRS
13	56	3	int (A)	'RRR': Row in WRS
13	59	2	string (A)	'AA': Acquisition station identifier.
Physical volume id				
14	61	2	string (A)	'AA': Processing station identifier. Part of the physical volume identifier.
14	63	1	string (A)	'Q': Quadrant number.
14	64	2	short (A)	'YY': Year of product generation.
14	66	3	int (A)	'DDD': Day of product generation.
14	69	6	dateTime (A)	'HHMMSS': Hour, minute and second of product generation.
14	75	1	byte (A)	'N': The CCT or Exabyte sequence number.
14	76	1	byte (A)	'n': The number of CCTs or exabytes generated for current product.
Volume set id				
15	77	8	string (A)	Satellite name. Part of the volume set identifier.

15	85	1	string (A)	Satellite number.
15	86	7	string (A)	Instrument.
16	93	2	short (A)	Number of physical volumes in the set. It indicates the total number of Physical volume in a Volume Set. A blank field indicates that the information is was not avalaible at the time the Logical Volume was recorded.
17	95	2	short (A)	Physical volume number, start of logical volume. This field indicates the sequence number of the Physical volume within a volume set, which contains the 1st record of the Logical Volume.
18	97	2	short (A)	Physical volume number, end of logical volume. 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.
19	99	2	short (A)	Physical volume sequence number (i.e of current tape) - 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 for field 17. The value in this field must lie within 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).
20	101	4	int (A)	First referenced file number in this physical volume. 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 number count.
21	105	4	int (A)	Logical volume number within volume set. 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	109	4	int (A)	Logical volume number within physical volume. This is the sequence number of the present Logical Volume within a Physical Volume.
23	113	8	dateTime (A)	Logical volume creation date (Generation date reference field). It indicates the date when the Logical Volume was recorded. The format is "YYYYMMDD", where YYYY is the year, MM the month and DD the day.
24	121	8	dateTime (A)	Logical volume creation time (Generation time reference field). It indicates the time when the Logical Volume was recorded. The form of the code is "HHMMSSXX", where HH is the hour, MM the minute, SS the second and XX is hundredths of seconds.
25	129	12	string (A)	Logical volume generating country. It indicates the name of the country generating this logical volume.
26	141	8	string (A)	Logical volume generating agency. It indicates the laboratory or the center generating this logical volume.
27	149	12	string (A)	Logical volume generating facility. It indicates the computer facility on which the logical volume was recorded.
28	161	4	int (A)	Number of pointer records in this volume directory. This gives the number of data files in the logical volume.
29	165	4	int (A)	Total number of records this in volume directory. This is the number of File pointers records plus one (for this record), plus the number of Text Records.
30	169	4	int (A)	Number of logical volumes in the set.
31	173	88	string (B)	Spare segment. Reserved for future revisions of this record format.
32	261	100	string (B)	Local use segment. When unused this field is filled with blanks.

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.

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 the following table.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	4	int (A)	Referenced file number. Sequence number within the Logical Volume of the file referenced by this pointer. This is also the sequence number of the File Pointer within the Volume Directory. The first file following the first Volume Directory (2nd file of the Logical Volume).
Referenced file name				
10	21	6	string (A)	Satellite name. Part of the referenced file name, which is the unique identification provided when the volume directory is created in order to specify the file referenced by this pointer.
10	27	2	short (A)	Correction level.
10	29	4	string (A)	File name.
10	33	3	string (A)	Interleaving indicator. (e.g. 'BSQ').
10	36	1	byte (A)	Band number associated to file name.
11	37	28	string (A)	Referenced file class. This is a description of the class to which the referenced file belongs. The class of a file is based on the nature of its content.
12	65	4	string (A)	Referenced file class code. The 4-character code for the class described in the previous field.
13	69	28	string (A)	Referenced file data type. This field indicates the data type contained in the referenced file.
14	97	4	string (A)	Referenced file data type code. The 4-character code for the data type described in the previous field.
15	101	8	int (A)	Number of records in the referenced file. If this number is unknown at the creation time, the field is left blank.
16	109	8	int (A)	Referenced file descriptor record length. This field gives 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	117	8	int (A)	Referenced file maximun record length. This field gives the length in bytes of the longest record other than the File Descriptor Record in the referenced file.

18	125	12	string (A)	Referenced file length type. This field gives the length type of the file records. For this format, fixed length records are used, so this field contains 'FIXED$LENGTH'.
19	137	4	string (A)	Referenced file length type code. The 4-character code for the record length type described in the previous field. For this format, the value is 'FIXD'.
20	141	2	short (A)	Referenced file physical volume, start of file. This field indicates the sequence number of the Physical volume which contains the 1st record of the referenced file. The field is left blank if information was unknown at the time of recording.
21	143	2	short (A)	Referenced file physical volume, end of file. This field indicates the sequence number of the Physical volume which contains the last record of the referenced file. The field is left blank if information was unknown at the time of recording.
22	145	8	int (A)	Referenced file portion, 1st record number. When a portion of the referenced file is on the PREVIOUS physical volume, this number is the one of the first record of the referenced file to be recorded on THIS physical volume. In all other conditions this number is set to 1. This field and the next one are the only fields in the file pointer record to be changed on a repeated volume directory. They are only changed in the file pointer record that refers to the split file.
23	153	8	int (A)	Referenced file portion, last record number. When a portion of the referenced file is on the NEXT physical volume, this number is the one of the last record of the referenced file to be recorded on THIS physical volume. See previous field for more detailed explanations.
24	161	100	string (B)	Spare segment. Reserved for future revisions of this record format.
25	261	100	string (B)	Local use segment. When unused this field is filled with blanks.

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 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 tape is being processed. The record contents are descibed in the table below.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	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$'.
9	17	50	string (A)	Product identifier. Format is "SSS$LSNXPPPRRRYYDDDCC" followed by blank characters, where 'SSS' is the sensor type, 'LSN' the Landsat mission number, 'X' the scene type (F for full scene, E for floating full scene, 1 to 4 for standard quarter quadrant, Q for floating quadrant, M for miniscene and O for microscene), 'PPP' the WRS path, 'RRR' the WRS row, 'YY' the last two digits of the year, 'DDD' the day of the year and 'CC' the correction level applied.
Product creation				

10	67	39	string (A)	Creation location. Part of the product creation description.
10	106	19	dateTime (A)	Creation date.
Scene identification				
11	125	1	byte (A)	Mission number. Part of the scene identification.
11	126	5	int (A)	Day number since launch at time of observation.
11	131	6	dateTime (A)	GMT time at which the center point was imaged. Format is 'HHMMSS' where 'HH' is the hour, 'MM' the minute and 'SS' the second.
12	137	4	string (A)	Scene type. Format is '$$$X', with X : F for full scene, E for floating full scene, 1 to 4 for standard quarter quadrant, Q for floating quadrant, M for miniscene and O for microscene.
13	141	4	string (A)	Interleaving type. (e.g. BSQ).
14	145	12	string (A)	Blanks.
Tape reel id				
15	157	2	string (A)	Processing station identifier. Part of the tape id.
15	159	1	string (A)	Quadrant number. F for full scene, E for floating full scene, 1 to 4 for standard quarter quadrant, Q for floating quadrant, M for miniscene and O for microscene.
15	160	2	short (A)	Year of generation.
15	162	3	int (A)	Day in year of generation.
15	165	6	dateTime (A)	Time of generation. Format is 'HHMMSS' where 'HH' is the hour, 'MM' the minute and 'SS' the second.
15	171	1	byte (A)	CCT or exabyte sequence number.
15	172	1	byte (A)	Number of CCT or exabyte generated for the current product.
16	173	4	string (A)	Blanks.
17	177	4	int (A)	HDDR identification.
18	181	16	string (A)	Spare.
Date of HDT generation				
19	197	2	short (A)	Year of HDT generation.
19	199	4	int (A)	Days of HDT generation.
Requested center scene latitude				
20	203	29	string (A)	Tag of the requested center scene latitude.
20	232	8	string (A)	Value of the requested center scene latitude. Format is "DDDMMSSO" with : 'DDD' for degrees, 'MM' for minutes, 'SS' for seconds and 'O' for orientation (N or S for north or south).
Requested center scene longitude				
21	240	29	string (A)	Tag of the requested center scene longitude.
21	269	8	string (A)	Value of the requested center scene longitude. Format is "DDDMMSSO" with : 'DDD' for degrees, 'MM' for minutes, 'SS' for seconds and 'O' for orientation (E or W for east or west).
Processed center scene latitude				
22	277	29	string (A)	Tag of the processed center scene latitude.
22	306	8	string (A)	Value of the processed center scene latitude. Format is "DDDMMSSO" with : 'DDD'

				for degrees, 'MM' for minutes, 'SS' for seconds and 'O' for orientation (N or S for north or south).
Processed center scene longitude				
23	314	29	string (A)	Tag of the processed center scene longitude.
23	343	8	string (A)	Value of the processed center scene longitude. Format is "DDDMMSSO" with : 'DDD' for degrees, 'MM' for minutes, 'SS' for seconds and 'O' for orientation (E or W for east or west).
24	351	10	string (A)	Blanks.

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 the table below.

The length of this record may vary according to the length of the other records of the file.

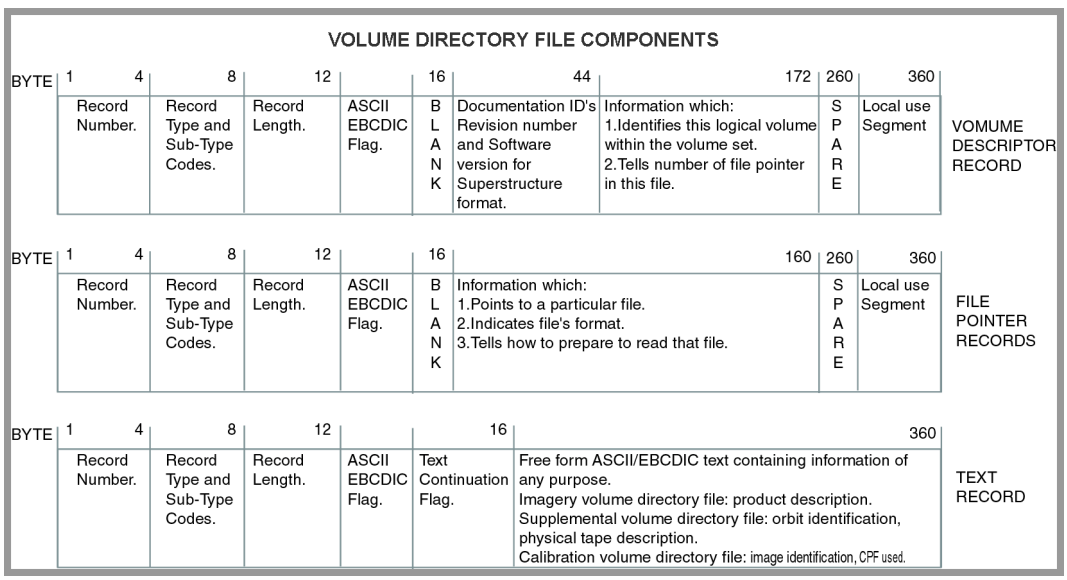
Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (B)	Blanks.
9	17	12	string (A)	Control document number for this data file - 12 characters containing the number for the documents that controls this file format.
10	29	2	short (A)	Control document revision number, from 01 to 99 - 2 bytes giving the revision number of the control document that controls this file format.
11	31	2	string (A)	Superstructure record format revision letter - 2 bytes giving the revision letter of the file format (as oppposed to revisons which affect the control document without affecting the file format).
12	33	12	string (A)	Software release number : "TMFR - VRX.X.X". 12 characters identifying the software version used to write this file.
13	45	4	int (A)	Sequence number of this file - 4-byte sequence number of this file within the Logical Volume exluding the vomume directory.
14	49	16	string (A)	Referenced file name depends on the level of correction applied - on the band number to which the associated imagery file relates.
15	65	4	string (A)	Record sequence and location type flag - This 4-byte field indicates if the others records in the file have sequence numbers.
16	69	8	int (A)	Sequence number location - These 8 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	77	4	int (A)	Sequence number field length - 4 bytes indicating, in bytes, the length of the record sequence number field.
18	81	4	string (A)	Record code and location type flag - 4 bytes flag to indiczte if the other records in the file have a record type code, and if the location of the code is fixed or varible.
19	85	8	int (A)	Record code location - These 8 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	93	4	int (A)	Record code field length - Four bytes indicating the length, in bytes, of the file type code field.
21	97	4	string (A)	Record length and location type flag - 4 byte flag to indicate if the other records in the file contain their record lenghts.
22	101	8	int (A)	Record length location - These 8 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. END OF FILE DESCRIPTOR FIXED SEGMENT.
23	109	4	int (A)	Record length field length - 4 bytes, indicating the length, in bytes, of the record length field.
24	113	1	string (A)	Flag indicating that data interpretation information is included within the file descriptor: Yes or No.
25	114	1	string (A)	Flag indicating that data interpretation information is included with the file descriptor: Yes or No.
26	115	1	string (A)	Flag indicating that display information is included within the file descriptor: Yes or No.
27	116	1	string (A)	Flag indicating that display information is included with the file descriptor: Yes or No.
28	117	64	string (B)	Reserved for future usage

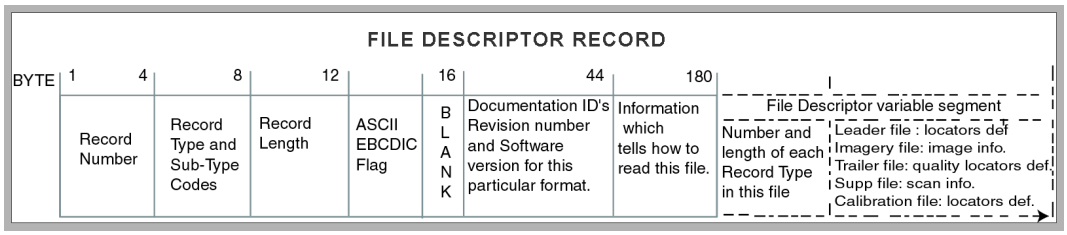
The format of the variable segment is unique to each individual file class, but several general rules are usually followed. For example, the number and length of up to three different record types may be specified. "Locators", giving the precise location and format of data considered to be important, 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. They are, 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.

Summary

The figures below present a summary of the superstructure records.



Volume Directory File Records summary



File Descriptor Record summary

Part

3

Imagery Logical Volume

Chapter 3.1 Volume Directory File

3.1.1 Overview

As introduced in the previous part, the product organization is based on a hierarchy of volumes, files, records and fields. All volumes have their own files structure except for one file, the Volume Directory File, which is present in all volume and has always the same definition.

The only file classes used for the ESA Landsat imagery logical volumes 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 constituent record types for each of the three file classes.

This file (VDF) is part of the standard family. A detailed definition is given in the "Standard Family" chapter and repeated here below.

3.1.2 Volume Descriptor Record

The table below details the structure of the Volume Descriptor Record. Fields 1 to 6 are binary encoded. All others fields are in ASCII. Alphanumeric character strings are by default left-justified and numeric character strings are right-justified. Any unused field is filled with ASCII blanks. Number which does not fill the field are padded with leading blanks.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	12	string (A)	Superstructure format control document identifier.
10	29	2	string (A)	Superstructure control document revision number. It indicates the revision number or letter of the Superstrucure Format Control Document. Coded $C, for the original draft.
11	31	2	string (A)	Superstucture record format revision letter. It indicates the revision letter of the Superstrucure records 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 Superstructure 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	33	12	string (A)	Superstructure software release number. It identifies the software revision used to write this logical volume.
Logical volume id				
13	45	3	string (A)	'MNS': Mission, Number and Sensor type (e.g. 'L7E' for Landsat 7 ETM). Part of the logical volume identifier.
13	48	2	short (A)	'YY': Year of acquisition

13	50	3	int (A)	'DDD': Day of acquisition
13	53	3	int (A)	'PPP': Path in WRS
13	56	3	int (A)	'RRR': Row in WRS
13	59	2	string (A)	'AA': Acquisition station identifier.
Physical volume id				
14	61	2	string (A)	'AA': Processing station identifier. Part of the physical volume identifier.
14	63	1	string (A)	'Q': Quadrant number.
14	64	2	short (A)	'YY': Year of product generation.
14	66	3	int (A)	'DDD': Day of product generation.
14	69	6	dateTime (A)	'HHMMSS': Hour, minute and second of product generation.
14	75	1	byte (A)	'N': The CCT or Exabyte sequence number.
14	76	1	byte (A)	'n': The number of CCTs or exabytes generated for current product.
Volume set id				
15	77	8	string (A)	Satellite name. Part of the volume set identifier.
15	85	1	string (A)	Satellite number.
15	86	7	string (A)	Instrument.
16	93	2	short (A)	Number of physical volumes in the set. It indicates the total number of Physical volume in a Volume Set. A blank field indicates that the information is was not avalaible at the time the Logical Volume was recorded.
17	95	2	short (A)	Physical volume number, start of logical volume. This field indicates the sequence number of the Physical volume within a volume set, which contains the 1st record of the Logical Volume.
18	97	2	short (A)	Physical volume number, end of logical volume. 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.
19	99	2	short (A)	Physical volume sequence number (i.e of current tape) - 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 for field 17. The value in this field must lie within 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).
20	101	4	int (A)	First referenced file number in this physical volume. 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 number count.
21	105	4	int (A)	Logical volume number within volume set. 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	109	4	int (A)	Logical volume number within physical volume. This is the sequence number of the present Logical Volume within a Physical Volume.
23	113	8	dateTime (A)	Logical volume creation date (Generation date reference field). It indicates the date when the Logical Volume was recorded. The format is "YYYYMMDD", where YYYY is the year, MM the month and DD the day.
24	121	8	dateTime (A)	Logical volume creation time (Generation time reference field). It indicates the time when the Logical Volume was recorded. The form of the code is "HHMMSSXX", where HH is the hour, MM the minute, SS the second and XX is hundredths of seconds.
25	129	12	string (A)	Logical volume generating country. It indicates the name of the country generating this logical volume.

26	141	8	string (A)	Logical volume generating agency. It indicates the laboratory or the center generating this logical volume.
27	149	12	string (A)	Logical volume generating facility. It indicates the computer facility on which the logical volume was recorded.
28	161	4	int (A)	Number of pointer records in this volume directory. This gives the number of data files in the logical volume.
29	165	4	int (A)	Total number of records this in volume directory. This is the number of File pointers records plus one (for this record), plus the number of Text Records.
30	169	4	int (A)	Number of logical volumes in the set.
31	173	88	string (B)	Spare segment. Reserved for future revisions of this record format.
32	261	100	string (B)	Local use segment. When unused this field is filled with blanks.

3.1.3 File Pointer Record

The table below details the structure of the File Pointer Record. Fields 1 to 6 are binary encoded. All others fields are in ASCII. Alphanumeric character strings are by default left-justified and numeric character strings are right-justified. Any unused field is filled with ASCII blanks. Number which does not fill the field are padded with leading blanks.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	4	int (A)	Referenced file number. Sequence number within the Logical Volume of the file referenced by this pointer. This is also the sequence number of the File Pointer within the Volume Directory. The first file following the first Volume Directory (2nd file of the Logical Volume).
Referenced file name				
10	21	6	string (A)	Satellite name. Part of the referenced file name, which is the unique identification provided when the volume directory is created in order to specify the file referenced by this pointer.
10	27	2	short (A)	Correction level.
10	29	4	string (A)	File name.
10	33	3	string (A)	Interleaving indicator. (e.g. 'BSQ').
10	36	1	byte (A)	Band number associated to file name.
11	37	28	string (A)	Referenced file class. This is a description of the class to which the referenced file belongs. The class of a file is based on the nature of its content.
12	65	4	string (A)	Referenced file class code. The 4-character code for the class described in the

				previous field.
13	69	28	string (A)	Referenced file data type. This field indicates the data type contained in the referenced file.
14	97	4	string (A)	Referenced file data type code. The 4-character code for the data type described in the previous field.
15	101	8	int (A)	Number of records in the referenced file. If this number is unknown at the creation time, the field is left blank.
16	109	8	int (A)	Referenced file descriptor record length. This field gives 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	117	8	int (A)	Referenced file maximun record length. This field gives the length in bytes of the longest record other than the File Descriptor Record in the referenced file.
18	125	12	string (A)	Referenced file length type. This field gives the length type of the file records. For this format, fixed length records are used, so this field contains 'FIXED$LENGTH'.
19	137	4	string (A)	Referenced file length type code. The 4-character code for the record length type described in the previous field. For this format, the value is 'FIXD'.
20	141	2	short (A)	Referenced file physical volume, start of file. This field indicates the sequence number of the Physical volume which contains the 1st record of the referenced file. The field is left blank if information was unknown at the time of recording.
21	143	2	short (A)	Referenced file physical volume, end of file. This field indicates the sequence number of the Physical volume which contains the last record of the referenced file. The field is left blank if information was unknown at the time of recording.
22	145	8	int (A)	Referenced file portion, 1st record number. When a portion of the referenced file is on the PREVIOUS physical volume, this number is the one of the first record of the referenced file to be recorded on THIS physical volume. In all other conditions this number is set to 1. This field and the next one are the only fields in the file pointer record to be changed on a repeated volume directory. They are only changed in the file pointer record that refers to the split file.
23	153	8	int (A)	Referenced file portion, last record number. When a portion of the referenced file is on the NEXT physical volume, this number is the one of the last record of the referenced file to be recorded on THIS physical volume. See previous field for more detailed explanations.
24	161	100	string (B)	Spare segment. Reserved for future revisions of this record format.
25	261	100	string (B)	Local use segment. When unused this field is filled with blanks.

3.1.4 Text Record

The table below details the structure of the Text Record. Fields 1 to 6 are binary encoded. All others fields are in ASCII. Alphanumeric character strings are by default left-justified and numeric character strings are right-justified. Any unused field is filled with ASCII blanks. Number which does not fill the field are padded with leading blanks.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).

7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	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$'.
9	17	50	string (A)	Product identifier. Format is "SSS$LSNXPPPRRRYYDDDCC" followed by blank characters, where 'SSS' is the sensor type, 'LSN' the Landsat mission number, 'X' the scene type (F for full scene, E for floating full scene, 1 to 4 for standard quarter quadrant, Q for floating quadrant, M for miniscene and O for microscene), 'PPP' the WRS path, 'RRR' the WRS row, 'YY' the last two digits of the year, 'DDD' the day of the year and 'CC' the correction level applied.
Product creation				
10	67	39	string (A)	Creation location. Part of the product creation description.
10	106	19	dateTime (A)	Creation date.
Scene identification				
11	125	1	byte (A)	Mission number. Part of the scene identification.
11	126	5	int (A)	Day number since launch at time of observation.
11	131	6	dateTime (A)	GMT time at which the center point was imaged. Format is 'HHMMSS' where 'HH' is the hour, 'MM' the minute and 'SS' the second.
12	137	4	string (A)	Scene type. Format is '$$$X', with X : F for full scene, E for floating full scene, 1 to 4 for standard quarter quadrant, Q for floating quadrant, M for miniscene and O for microscene.
13	141	4	string (A)	Interleaving type. (e.g. BSQ).
14	145	12	string (A)	Blanks.
Tape reel id				
15	157	2	string (A)	Processing station identifier. Part of the tape id.
15	159	1	string (A)	Quadrant number. F for full scene, E for floating full scene, 1 to 4 for standard quarter quadrant, Q for floating quadrant, M for miniscene and O for microscene.
15	160	2	short (A)	Year of generation.
15	162	3	int (A)	Day in year of generation.
15	165	6	dateTime (A)	Time of generation. Format is 'HHMMSS' where 'HH' is the hour, 'MM' the minute and 'SS' the second.
15	171	1	byte (A)	CCT or exabyte sequence number.
15	172	1	byte (A)	Number of CCT or exabyte generated for the current product.
16	173	4	string (A)	Blanks.
17	177	4	int (A)	HDDR identification.
18	181	16	string (A)	Spare.
Date of HDT generation				
19	197	2	short (A)	Year of HDT generation.
19	199	4	int (A)	Days of HDT generation.
Requested center scene latitude				
20	203	29	string (A)	Tag of the requested center scene latitude.
20	232	8	string (A)	Value of the requested center scene latitude. Format is "DDDMMSSO" with : 'DDD' for degrees, 'MM' for minutes, 'SS' for seconds and 'O' for orientation (N or S for north

				or south).
Requested center scene longitude				
21	240	29	string (A)	Tag of the requested center scene longitude.
21	269	8	string (A)	Value of the requested center scene longitude. Format is "DDDMMSSO" with : 'DDD' for degrees, 'MM' for minutes, 'SS' for seconds and 'O' for orientation (E or W for east or west).
Processed center scene latitude				
22	277	29	string (A)	Tag of the processed center scene latitude.
22	306	8	string (A)	Value of the processed center scene latitude. Format is "DDDMMSSO" with : 'DDD' for degrees, 'MM' for minutes, 'SS' for seconds and 'O' for orientation (N or S for north or south).
Processed center scene longitude				
23	314	29	string (A)	Tag of the processed center scene longitude.
23	343	8	string (A)	Value of the processed center scene longitude. Format is "DDDMMSSO" with : 'DDD' for degrees, 'MM' for minutes, 'SS' for seconds and 'O' for orientation (E or W for east or west).
24	351	10	string (A)	Blanks.

Chapter 3.2 Leader File

3.2.1 Overview

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.

3.2.2 File Descriptor Record

A detailed definition of the file descriptor record fixed segment is given in the "Standard Family" chapter and is repeated here below.

The length of this record is 4320 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (B)	Blanks.
9	17	12	string (A)	Control document number for this data file - 12 characters containing the number for the documents that controls this file format.
10	29	2	short (A)	Control document revision number, from 01 to 99 - 2 bytes giving the revision number of the control document that controls this file format.
11	31	2	string (A)	Superstructure record format revision letter - 2 bytes giving the revision letter of the file format (as oppposed to revisons which affect the control document without affecting the file format).
12	33	12	string (A)	Software release number : "TMFR - VRX.X.X". 12 characters identifying the software version used to write this file.
13	45	4	int (A)	Sequence number of this file - 4-byte sequence number of this file within the Logical Volume exluding the vomume directory.
14	49	16	string (A)	Referenced file name depends on the level of correction applied - on the band number to which the associated imagery file relates.'LSsmmmlLEADiiib' where LS is

				the satellite name, s (4,5,7) is the satel lite numbber, mmm is the spectral mode (MSS, TM, ETM), ll the processing level (03,04,05), LEAD the file clas s, iii the interleaving indicator (BSQ, BIL) and b the band number.
15	65	4	string (A)	Record sequence and location type flag - This 4-byte field indicates if the others records in the file have sequence numbers.
16	69	8	int (A)	Sequence number location - These 8 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	77	4	int (A)	Sequence number field length - 4 bytes indicating, in bytes, the length of the record sequence number field.
18	81	4	string (A)	Record code and location type flag - 4 bytes flag to indiczte if the other records in the file have a record type code, and if the location of the code is fixed or varible.
19	85	8	int (A)	Record code location - These 8 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	93	4	int (A)	Record code field length - Four bytes indicating the length, in bytes, of the file type code field.
21	97	4	string (A)	Record length and location type flag - 4 byte flag to indicate if the other records in the file contain their record lenghts.
22	101	8	int (A)	Record length location - These 8 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. END OF FILE DESCRIPTOR FIXED SEGMENT.
23	109	4	int (A)	Record length field length - 4 bytes, indicating the length, in bytes, of the record length field.
24	113	1	string (A)	Flag indicating that data interpretation information is included within the file descriptor: Yes or No.
25	114	1	string (A)	Flag indicating that data interpretation information is included with the file descriptor: Yes or No.
26	115	1	string (A)	Flag indicating that display information is included within the file descriptor: Yes or No.
27	116	1	string (A)	Flag indicating that display information is included with the file descriptor: Yes or No.
28	117	64	string (B)	Reserved for future usage
29	181	6	int (A)	Number of scene header records.
30	187	6	int (A)	Scene header record length.
31	193	6	int (A)	Number of map ancillary records.
32	199	6	int (A)	Ancillary record length.
33	205	6	int (A)	Number of radiometric calibration ancillary records.
34	211	6	int (A)	Radiometric calibration ancillary record length.
35	217	16	string (A)	Scene identification field locator.
36	233	16	string (A)	WRS identification field locator.
37	249	16	string (A)	Mission identification field locator.
38	265	16	string (A)	Sensor identification field locator.
39	281	16	string (A)	TBC Exposure date time field locator - scene center and date time locator.
40	297	16	string (A)	Geographic reference field locator
41	313	16	string (A)	Image processing performed field locator.
42	329	16	string (A)	Imagery format indicator locator.
43	345	16	string (A)	Band indicator locator.
44	361	16	string (A)	Subscene indicator locator.

45	377	16	string (A)	Pixel size field locator.
46	393	16	string (A)	Number of interquadrant overlap lines indicator field locators.
47	409	16	string (A)	Number of interquadrant overlap pixels indicator field locators.
48	425	3896	string (A)	Blanks

File Descriptor Record 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

3.2.3 Scene Header Record

The scene header record 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.

Scene Parameters (bytes 21 to 308)

The first set defines the scene parameters, such as path, row, quadrant which is contained within the logical volume, and the full scene of which the quadrant forms a part.

Mission Parameters (bytes 309 to 372)

The second set relates to fixed information about the mission, such as platform and sensor names, orbit number and acsending/descending flag.

Sensor and Image Parameters (bytes 373 to 1476)

The third set defines the sensor parameters, such as the number of active bands, the number of lines and the number of pixels in the processed image.

Processing Parameters (bytes 1477 to 2280)

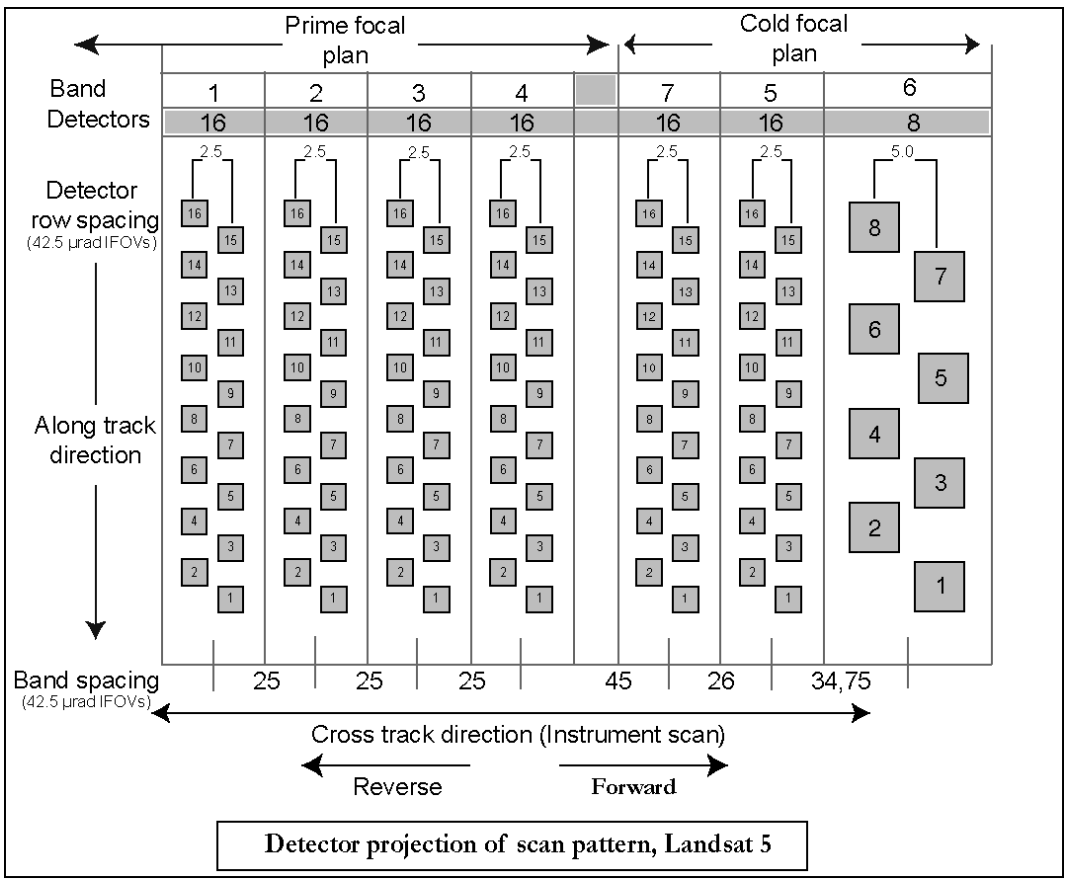
The fourth set indicates the processing options, such as radiometric calibration, resolution and correction, geometric correction, resampling algorithm, map projection, processing level and gain setting. In addition, this set contains two arrays related to detector substitution and smoothing technique, where detector numbering convention is the following:

- **For TM sensor:**
    - Bytes 1 to 16: Band 1, Detectors 1-16.
    - Bytes 17 to 32: Band 2, Detectors 1-16.
    - Bytes 33 to 48: Band 3, Detectors 1-16.
    - Bytes 49 to 64: Band 4, Detectors 1-16.
    - Bytes 65 to 80: Band 5, Detectors 1-16.

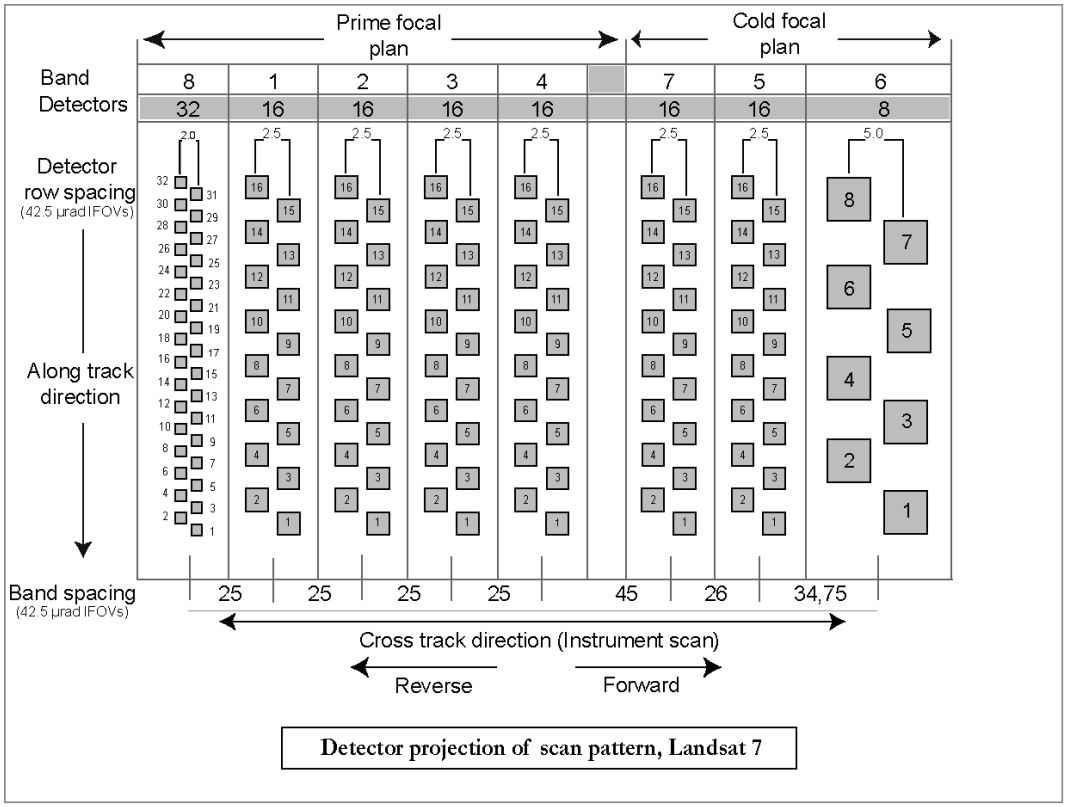
- Bytes 81 to 84: Band 6, Detectors 1-4.
- Bytes 85 to 100: Band 7, Detectors 1-16.

- **For ETM+ sensor:**
  - Bytes 1 to 16: Band 1, Detectors 1-16.
  - Bytes 17 to 32: Band 2, Detectors 1-16.
  - Bytes 33 to 48: Band 3, Detectors 1-16.
  - Bytes 49 to 64: Band 4, Detectors 1-16.
  - Bytes 65 to 80: Band 5, Detectors 1-16.
  - Bytes 81 to 88: Band 6L, Detectors 1-8.
  - Bytes 89 to 104: Band 7, Detectors 1-16.
  - Bytes 105 to 112: Band 6H, Detectors 1-8.
  - Bytes 113 to 144: Band PAN, Detectors 1-32.

The following figures present the detectors for TM and ETM+ sensors.



Landsat TM detectors



Landsat ETM+ detectors

The length of this record is 4320 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	4	int (A)	Header record sequence number.
8	17	4	string (A)	Blanks.
Product id				
9	21	3	string (A)	'SSS': Sensor type (e.g 'ETM'). Part of the product identifier (format 'SSS$LSNXPPPRRRYYDDDCC$').
9	24	1	string (A)	'$': Blank.
9	25	3	string (A)	'LSN': Landsat Mission (e.g. 'LS7').
9	28	1	string (A)	'X': Quadrant Number. F for full scene, E for floating full scene, 1 to 4 for standard quarter quadrant, Q for floating quadrant, M for miniscene and O for microscene.
9	29	3	int (A)	'PPP': Path Number.

9	32	3	int (A)	'RRR': Row Number.
9	35	2	short (A)	'YY': Last two digits of year.
9	37	3	int (A)	'DDD': Day of year.
9	40	2	short (A)	'CC': Correction Applied.
9	42	1	string (A)	'$': Blank.
input_scene_id				
10	43	1	byte (A)	'L': Mission number. Part of the input scene identifier (format 'LDDDDHHMM$').
10	44	4	int (A)	'DDDD': Day number since launch.
10	48	4	dateTime (A)	'HHMM': Time of center point. Where 'HH' are hours and 'MM' minutes.
10	52	1	string (A)	'$': Blank.
11	53	16	float (A)	Input scene center (frame) latitude in degrees.
12	69	16	float (A)	Input scene (frame) center longitude in degrees.
13	85	16	float (A)	Line number at input scene center.
14	101	16	float (A)	Pixel number at input scene center.
Full scene center				
15	117	8	dateTime (A)	'YYYMMDD': Full scene center date. Where 'YYYY' is the year, 'MM' the month and 'DD' the day.
15	125	6	dateTime (A)	'HHMMSS': Full scene center time. Where 'HH' are hours, 'MM' minutes and 'SS' seconds.
15	131	18	string (A)	Blanks.
16	149	16	int (A)	Time offset from WRS frame (msecs). Time offset in milliseconds from stansard framing corresponding to the World Reference System.
WRS designator				
17	165	1	string (A)	Ascending/Descending node. Part of the WRS designator. 'A' if Ascending node or 'D' if Descending node.
17	166	3	int (A)	'PPP': Nominal path number ('001' to '233').
17	169	12	int (A)	'RRR': Nominal row number ('001' to '248').
18	181	16	int (A)	WRS cycle. A cycle corresponds to 233 paths.
Processed scene id				
19	197	1	byte (A)	'L': Mission Number. Part of the processed scene identifier (format 'LDDDDHHMMSSX$$$$').
19	198	4	int (A)	'DDDD': Day number since launch.
19	202	6	dateTime (A)	'HHMMSS': Time of center point. Where 'HH' are hours, 'MM' minutes and 'SS' seconds in GMT at which the center point was imaged.
19	208	1	string (A)	'X': Quadrant Number. F for full scene, E for floating full scene, 1 to 4 for standard quarter quadrant, Q for floating quadrant, M for miniscene and O for microscene.
19	209	4	string (A)	Blanks.
20	213	16	float (A)	Processed scene center (frame/quadrant) latitude in degrees.
21	229	16	float (A)	Processed scene center (frame/quadrant) longitude in degrees.
22	245	16	float (A)	Line number at processed scene (frame/quadrant) center.

23	261	16	float (A)	Pixel number at processed scene (frame/quadrant) center.
24	277	16	int (A)	Count of overlap lines. This is the number, L, of overlap lines which belong to the quadrant immediately above (or below) the current quadrant. In case of full frame this number is set to 0.
25	293	16	int (A)	Count of overlap pixels. This is the number, P, of overlap pixels, counted in one direction only, defined as being the number of pixels which belong to the adjacent quadrant. In case of full frame this number is set to 0.
Mission parameters				
26	309	16	string (A)	Mission identification (e.g. 'LANDSAT-7' followed by blanks).
27	325	16	string (A)	Sensor identification (e.g. 'ETM' followed by blanks).
28	341	16	string (A)	Orbit number.
29	357	16	string (A)	Orbital direction. Ascending/descending flag, set to 'A' for ascending paths and to 'D' for descending paths, followed by blanks.
30	373	16	string (A)	Blanks.
31	389	1024	string (A)	Blanks for local use.
32	1413	16	int (A)	Number of active bands in the processed image. The total number of actives 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	16	int (A)	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	16	int (A)	Number of scene lines in the processed image. This is the actual number of scenes lines in the imagery file following this Leader File.
35	1461	16	string (A)	Blanks.
Radiometric calibration designator				
36	1477	1	string (A)	III Internal calibration source. Part of the radiometric calibration designator, which is a set of 16 1-byte codes, each specifying whether the identified correction has been applied (value = 'Y') or not (value = 'N').
36	1478	1	string (A)	Pre-flight data. (already used by ACS for calibration).
36	1479	1	string (A)	Histogram equalization.
36	1480	1	string (A)	Sun elevation correction.
36	1481	1	string (A)	Film gamma correction.
36	1482	1	string (A)	Scenic correction.
36	1483	1	string (A)	Histogram mean and standard deviation.
36	1484	1	string (A)	Blank.
36	1485	1	string (A)	Blank.
36	1486	1	string (A)	Gain seeting rules. 'L' for low gain, 'H' for high gain.
36	1487	1 x6	string (A)	Agencies codes. May be used by other agencies codes to store radiometric processing codes.
37	1493	16	int (A)	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.
Scenic radiometric correction designator				
38	1509	1	string (A)	Completly raw data. Part of the scenic radiometric correction designator, which is a set of 16 1-byte codes, each specifying whether the identified correction has been applied (value = 'Y') or not (value = 'N').

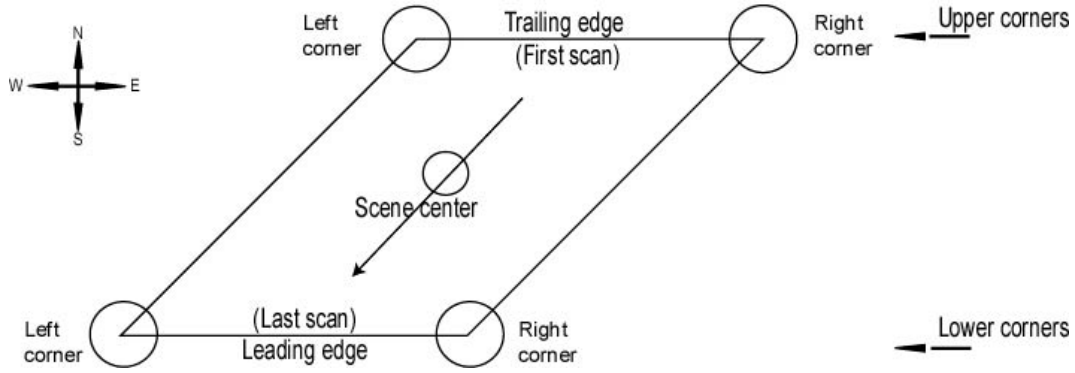
38	1510	1	string (A)	Linear representation.
38	1511	1	string (A)	Logarithmic representation.
38	1512	1	string (A)	Other non-linear representation.
38	1513	1	string (A)	Reserved.
38	1514	1	string (A)	Sun illumination angle correction.
38	1515	1	string (A)	Haze correction.
38	1516	1	string (A)	Sun illuminaion angle and haze correction.
38	1517	1	string (A)	Standard radiometric enhancement.
38	1518	1	string (A)	Rangeland enhancement.
38	1519	1	string (A)	Foresty enhancement.
38	1520	1	string (A)	Custom enhancement.
38	1521	1	string (A)	Atmospheric correction.
38	1522	1 x3	string (A)	Unused.
Geometric correction designator				
39	1525	1	string (A)	Forward/reverse alignment. Part of the geometric correction designator, which is a set of 16 1-byte codes, each specifying whether the identified correction has been applied (value = 'Y') or not (value = 'N').
39	1526	1	string (A)	Detector placement and delay.
39	1527	1	string (A)	Mirror scan profile.
39	1528	1	string (A)	Line length information.
39	1529	1	string (A)	Gyro data.
39	1530	1	string (A)	Angular displacement sensor (ADS) data.
39	1531	1	string (A)	Attitude correction system (ACS) data.
39	1532	1	string (A)	Ephemeris data.
39	1533	1	string (A)	Scan gap.
39	1534	1	string (A)	Ground control points.
39	1535	1	string (A)	Earth rotation.
39	1536	1	string (A)	Sensor altitude and panoramic distortion.
39	1537	1	string (A)	Digital terrain model (DTM).
39	1538	1	string (A)	PCD available or not.
39	1539	2	string (A)	Ephemeris used. Set to 'P' for PCD, 'D' for Definitive or blank if unknown.
Map resampling designator				
40	1541	1	string (A)	No resampling. Part of the map resampling algorithm designator, which is a set of 1-byte codes, each specifying whether the identified algorithm has been applied (value = 'Y') or not (value = 'N').
40	1542	1	string (A)	Resampling along line only.
40	1543	1	string (A)	Two-dimension resampling.
40	1544	1 x9	string (A)	Unused.
40	1553	4	string (A)	'XXXX': Resampling method identification. 'NONE' for None (always applicable on raw products), 'NN$$' for Nearest neighbour, 'CC$$' for Cubic convolution, 'S8$$' for 8-point sin(x)/x, 'DS8$' for 8-point damped sin(x)/x, 'S16$' for 16-point sin(x)/x, 'DS16' for 16-point damped sin(x)/x, 'BLI$' for Bilinear interpolation and 'PSD$' for Pixel

				stuff/delete.
Map projection identifier				
41	1557	1	string (A)	No projection. Part of the map projection identifier, which is a set of 1-byte codes, each specifying whether the identified projection has been applied (value = 'Y') or not (value = 'N').
41	1558	1	string (A)	UTM/Polar stereographic.
41	1559	1	string (A)	SOM (Space Oblique Mercator).
41	1560	1	string (A)	Geocoded product.
41	1561	12	string (A)	Blanks.
42	1573	16	int (A)	Product processing level. It is stored as two numerical characters representing the overall level of corrections applied. See table.
43	1589	16	int (A)	Number of map projection ancillary records.
44	1605	16	string (A)	Blanks.
45	1621	16	string (A)	Blanks.
46	1637	16	int (A)	Number of radiometric ancillary records.
47	1653	64	string (A)	Active bands. One byte per band, with a maximum of n=64 bands where each byte is set to 1 if the related band is active, and set to 0 otherwise. For ETM n=9 and the remaining bytes are set to blank.
48	1717	16	string (A)	Interleaving indicator. (e.g. BSQ).
49	1733	4 x100	string (B)	Detector substitution array. For TM, this may be considered as an array of size 100 4-bytes ASCII elements, 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. For ETM, this field contains information only on detectors relative to the current band. See tables related to detector numbering convention.
50	2133	1 x100	string (B)	Detector smoothing array. For TM, this may be considered as an array of size 100 1-bytes ASCII elements, one element for each of the 100 TM detectors. A 1-byte ASCII code is used to signify the smoothing technique used. A blank code indicates no smoothing has been applied. For ETM, this field contains information only relative to the current band.
51	2233	4	int (A)	Pixel offset of the upper left corner within the full input scene.
52	2237	4	int (A)	Line offset of the upper left corner within the full scene.
53	2241	20	double (A)	Current calibration gain. Same value in radiometric ancillary record if "Pre-flight" calibration. Same value in imagery file suffix if "In-flight" calibration.
54	2261	20	double (A)	Current calibration offset - Same value in radiometric ancillary record if "Pre-flight" calibration. Same value in imagery file suffix if "In-flight" calibration.
55	2281	44	string (A)	Local use.
56	2325	1996	string (B)	Spare.

3.2.4 Map Projection Ancillary Record

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

All references to the input scene refer to the full WRS frame (see definition in Part 1), whereas all references to the processed scene refer to the quadrant or to the full scene. The figure below describes the scene centre and corners convention for descending path.



Descending path

The length of this record is 4320 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	16	int (A)	Map projection data - Input line nominal number of scene pixels. 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. conventions.
8	29	16	int (A)	Input image nominal number of scene lines.
9	45	16	float (A)	Nominal scale of inter-pixel distance in the uncorrected image, in metres at nadir.
10	61	16	float (A)	Nominal scale of input inter-line distance in the uncorrected image, in metres at nadir.
11	77	16	float (A)	Image skew at scene center.
UTM Coordinates				
12	93	5	string (A)	UTM datum for input image (e.g. 'GRS80').
12	98	11	int (A)	UTM zone number for input image.
13	109	16	float (A)	Nominal WRS northing of center in metres.
14	125	16	float (A)	Nominal WRS easting of center in metres.
15	141	16	float (A)	Northing of input image center in metres.
16	157	16	float (A)	Easting of input image center in metres.
17	173	16	float (A)	Vertical offset of scene center to WRS nominal center.
18	189	16	float (A)	Horizontal offset of scene center to WRS nominal center.
19	205	16	double (A)	Orientation of input image center in degrees (angle of projection axis from true north).
20	221	112	string (B)	Blanks (reserved for SOM related data).
21	333	16	int (A)	Processed scene related data - Number of pixels per line of processed image.

22	349	16	int (A)	Number of lines per processed image.
23	365	16	float (A)	Scale of processed inter-pixel distance in metres.
24	381	16	float (A)	Scale of processed inter-line distance in metres.
25	397	16	int (A)	UTM zone number for processed image.
26	413	16	float (A)	Line number in processed image at scene center.
27	429	16	float (A)	Pixel number in processed scene at scene center.
28	445	16	float (A)	Orientation of processed image center.
29	461	16	float (A)	Nominal spacecraft orbital inclination.
30	477	16	float (A)	Nominal ascending node (longitude at equator).
31	493	16	float (A)	Nominal spacecraft altitude in metres.
32	509	16	float (A)	Nominal ground speed in metres per second.
33	525	16	float (A)	Satellite heading at full scene center in degrees. Real subsatellite track direction angle, including earth rotation at the scene center of the image.
34	541	16	string (B)	Spare (zero-fill).
35	557	16	float (A)	Cross-track field of view in degrees.
36	573	16	float (A)	Sensor scan rate in scans per second.
37	589	16	float (A)	Sensor active sampling rate in samples per second.
38	605	16	float (A)	Sun elevation angle at WRS centre in degrees. Usefull to check the gain status.
39	621	16	float (A)	Sun azimuth angle at WRS center in degrees.
40	637	16	float (A)	Top left corner latitude (degrees).
41	653	16	float (A)	Top left corner longitude (degrees).
42	669	16	float (A)	Top right corner latitude (degrees).
43	685	16	float (A)	Top right corner longitude (degrees).
44	701	16	float (A)	Bottom left corner latitude (degrees).
45	717	16	float (A)	Bottom left corner longitude (degrees).
46	733	16	float (A)	Bottom right corner latitude (degrees).
47	749	16	float (A)	Bottom right corner longitude (degrees).
48	765	3555	string (A)	Blanks.

3.2.5 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 scene radiance or scene reflectance radiance 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.

The length of this record is 4320 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code

3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code
5	8	1	unsignedByte (B)	3rd record sub-type code
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	4	int (A)	Band number.
8	17	4	int (A)	Lower radiance limit, Lmin (unit 10*watt/m2*strad*micron).
9	21	4	int (A)	Upper radiance limit, Lmax (unit 10*watt/m2*strad*micron).
10	25	4	string (A)	Blanks
11	29	20	double (A)	Offset coefficient (A0), A0= Lmin.
12	49	20	double (A)	Gain coefficient (A1), A1=(Lmax-Lmin)/255.
13	69	1 x256	unsignedByte (B)	Detector 1 lookup table.
14	325	1 x256	unsignedByte (B)	Detector 2 lookup table.
15	581	1 x256	unsignedByte (B)	Detector 3 lookup table.
16	837	1 x256	unsignedByte (B)	Detector 4 lookup table.
17	1093	1 x256	unsignedByte (B)	Detector 5 lookup table.
18	1349	1 x256	unsignedByte (B)	Detector 6 lookup table.
19	1605	1 x256	unsignedByte (B)	Detector 7 lookup table.
20	1861	1 x256	unsignedByte (B)	Detector 8 lookup table.
21	2117	1 x256	unsignedByte (B)	Detector 9 lookup table.
22	2373	1 x256	unsignedByte (B)	Detector 10 lookup table.
23	2629	1 x256	unsignedByte (B)	Detector 11 lookup table.
24	2885	1 x256	unsignedByte (B)	Detector 12 lookup table.
25	3141	1 x256	unsignedByte (B)	Detector 13 lookup table.
26	3397	1 x256	unsignedByte (B)	Detector 14 lookup table.
27	3653	1 x256	unsignedByte (B)	Detector 15 lookup table.
28	3909	1 x256	unsignedByte (B)	Detector 16 lookup table.
29	4165	16	float (A)	Radiance to reflectance conversion factor.
30	4181	1 x16	byte (A)	Aerosol optical thickness (AOT). 1 Byte_value per each grid point. AOT value = Byte_Value/(100-0.1).
31	4197	16	int (A)	AOT standard deviation multiplied by 100.
32	4213	2 x16	short (B)	View zenith angles in degress multiplied by 100.

33	4245	2 x16	short (B)	View zenith angles in degrees multiplied by 100
34	4277	2 x16	short (B)	Relative azimuth angles in degrees multiplied by 100. 2 bytes per each grid point. The Relative Azimuth agles is the difference between the Sun elevation and the View Azimuth Angle.
35	4309	2	short (B)	Water Vapor content (g/cm2) multiplied by 1000.
36	4311	1	string (A)	Water Vapor origin: - =M, if extracted from ECMWF database - =C, if climatological - =D, if default.
37	4312	2	short (B)	Ozone content (cm x atm) multiplied by 1000.
38	4314	1	string (A)	Ozone origin: =T, if extracted from ECMWF database - =C, if climatological.
39	4315	2	short (B)	Surface pressure (millibar) multiplied by 10
40	4317	1	string (A)	Surface pressure origin: =M, if from ECMWF database - =E, if from ETOPO5 model - =D, if default.
41	4318	2	short (B)	Surface Temperature (Kelvin degrees) multiplied by 100.
42	4320	1	string (A)	Surface Temperature origin: =M, if from ECMWF database.

Chapter 3.3 Imagery File

3.3.1 Overview

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 that 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 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 is Band Sequential (BSQ), where the file contains image data for one spectral band only. The imagery file contains one file descriptor record, and image records containing full, half or portion of 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).

The length of the imagery data file records is variable, depending on the quadrant and if the product is path-oriented or map-oriented. 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.

3.3.2 File Descriptor Record

A detailed definition of the file descriptor record fixed segment is given in the "Standard Family" chapter and is repeated here below.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (B)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	12	string (A)	Control document number for this data file format.
10	29	2	short (A)	Control document revision number
11	31	2	string (A)	File design descriptor revision letter.
12	33	12	string (A)	Software release number.

13	45	4	int (A)	File number.
14	49	16	string (A)	File name.
15	65	4	string (A)	Record sequence and location type flag.
16	69	8	int (A)	Sequence number location.
17	77	4	int (A)	Sequence number field length.
18	81	4	string (A)	Record code and location type flag.
19	85	8	int (A)	Record code location.
20	93	4	int (A)	Record code field length.
21	97	4	string (A)	Record length and location type flag.
22	101	8	int (A)	Record length location.
23	109	4	int (A)	Record length field length.
24	113	1	string (A)	Flag on data interpretation information within file descriptor record.
25	114	1	string (A)	Flag on data interpretation information within other file record
26	115	1	string (A)	Flag on data display information within file descriptor record
27	116	1	string (A)	Flag on data display information within other file record
28	117	64	string (B)	Reserved
29	181	6	int (A)	Number of record in the file
30	187	6	int (A)	Image record length
31	193	24	string (B)	Reserved.
32	217	4	int (A)	Pixel group data: Number of bits per pixel.
33	221	4	int (A)	Pixel group data: Number of pixel per data group.
34	225	4	int (A)	Pixel group data: Number of bytes per data group.
35	229	4	string (A)	Pixel group data: Justification and order of pixels within data group: RJLR.
36	233	4	int (A)	Number of images in this file.
37	237	8	int (A)	Image data: Number of lines per image in one band,see table related to scene type, bytes size, number of lines, and record length.
38	245	4	int (A)	Image data: Number of left border pixels per line.
39	249	8	int (A)	Image data: Number of image pixels per line.
40	257	4	int (A)	Image data: Number of border pixels to the right of image.
41	261	4	int (A)	Image data: Number of top border lines.
42	265	4	int (A)	Image data: Number of bottom border lines.
43	269	4	string (A)	Image data: Type of band interleaving: BSQ.
44	273	2	short (A)	Record data: Number of physical records per monospectral line.
45	275	2	short (A)	Record data: Number of physical records per multispectral line.
46	277	4	int (A)	Record data: Number of bytes of prefix data per record.
47	281	8	int (A)	Record data: Number of bytes of image data per record.
48	289	4	int (A)	Record data: Number of bytes of suffix support data field following the image data.
49	293	4	string (A)	Record data: Prefix/suffix repeat flag.
50	297	8	string (A)	Prefix/Suffix data locators: Scan line number locator.
51	305	8	string (A)	Prefix/Suffix data locators: Spectral band number locator

52	313	8	string (A)	Prefix/Suffix data locators: Time of scan line locator
53	321	8	string (A)	Prefix/Suffix data locators: Left-fill count locator.
54	329	8	string (A)	Prefix/Suffix data locators: Right-fill count locator.
55	337	32	string (A)	Prefix/Suffix data locators: Blanks.
56	369	8	string (A)	Prefix/Suffix data locators: Scan line quality code locator.
57	377	8	string (A)	Prefix/Suffix data locators: Calibration information field.
58	385	8	string (A)	Prefix/Suffix data locators: Gain values field locator.
59	393	8	string (A)	Bias values field locator
60	401	32	string (A)	Prefix/Suffix data locators: Blanks.
61	433	4	int (A)	Pixel data: Number of left fill bits within pixel
62	437	4	int (A)	Pixel data: Number of right fill bits within pixel
63	441	8	int (A)	Pixel data: Maximum data range of pixel
64	449		string (A)	Pixel data: Blanks

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.

3.3.3 Image Record

The definition of the image record is reproduced here in detail.

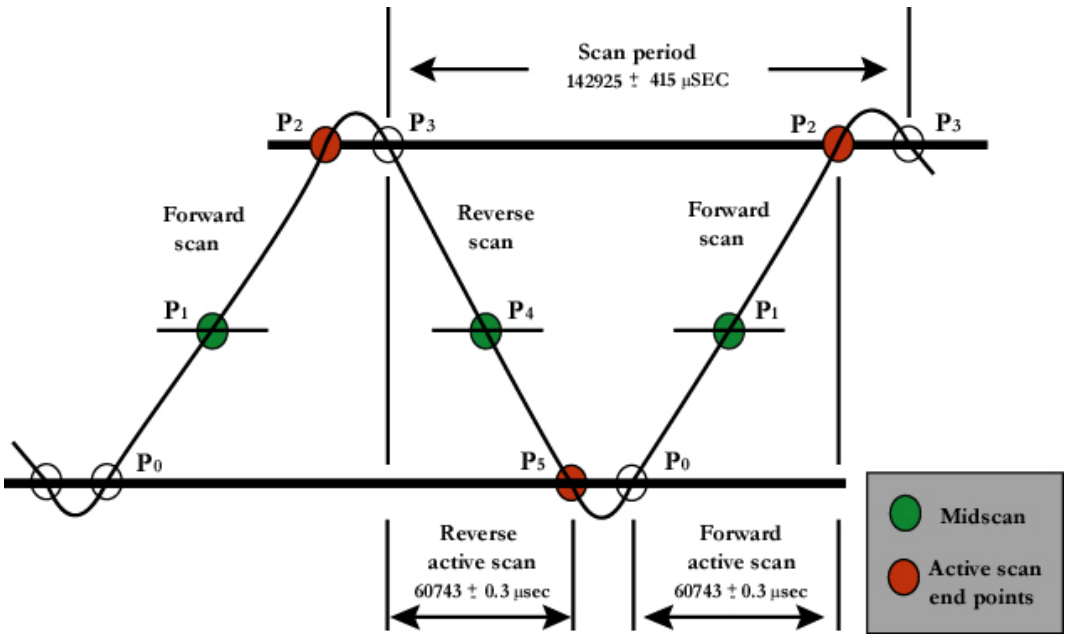
Each image record contains the following groups of data:

- The twelve bytes of standard record introductory data (i.e. record number, record type and sub-types, and record length)
- Twenty bytes of prefix data
- A variable number of bytes of raw or corrected image data. The variable length is described in the following table:

Scene	Band	Length	Lines	Pixels
Full	1-7	7020	5960	6920
	PAN	13940	11920	13840
Quarter	1-7	3600	3044	3500
	PAN	7100	6088	7000
Mini	1-7	2284	1836	2184
	PAN	4468	3672	4368
Micro	1-7	1286	836	1188
	PAN	2472	1672	2376

Image record size

- Sixty-eight bytes of suffix data. These data are calculated after acquisition and related to the line aquired by a specific detector. In particular the suffix data contain the detector identification, the scan direction, and time errors measured from start of scan to midscan and from midscan to end of scan. These errors are expressed in clock counts and allows the refinement of the mirror velocity profile polynom, used for the geometric correction of each swath. At last, suffix data contain calibration lamps states, gain and bias values. The following figure presents the mirror profile steps.



Mirror profile

Most of the prefix data and suffix data are located by the file descriptor record variable segment for the imagery file.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	4	unsignedInt (B)	Prefix data - Scan line number. This number is relative to the start of video data loaded (as swath index). It is used to relate video and calibration data.
8	17	4	unsignedInt (B)	Image (band) number.
9	21	4	int (B)	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 avalaible.
10	25	4	unsignedInt (B)	Count of left fill pixels. The count of left fill pixels the pad pixels inserted for geometric corrections, such as earth rotation correction.
11	29	4	unsignedInt (B)	Count of right fill pixels.
12	33	1 xN	unsignedByte (B)	Image data: Image pixels, pad pixels included.
13	1	1	unsignedByte (B)	Suffix Data: Synchro loss flag. It is the sync loss indicator for the current line. It is set to 1 if synchronisation is lost and to 0 otherwise.
14	2	1	unsignedByte (B)	Local use quality code. It is a quality control flag, set to 0 under normal conditions and 1 if error occurs.
15	3	1	unsignedByte (B)	Detector substitution indicator is set to 1, if video data for the line was substituted for another detector.
16	4	1 x5	unsignedByte (B)	Local use quality code, quality control flag, set to 0 under normal conditions and 1 if error occurs.
17	9	4	unsignedInt (B)	Counted full-scan line length. This is the number of pixels counted in the original geometricaly uncorrected scan line.
18	13	4	unsignedInt (B)	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	17	2	unsignedShort (B)	Time error from line start to midscan or first half scan error (FHSERR). The time error in clock counts from nominal line start to midscan count of 161,164 can be converted to time error in microseconds by multiplying by R=1/(DataRate/16). Where DataRate = 84.903 Mbps. A clock pulse is equal to 0.18845 microseconds, thus by multiplying with 161,164, it gives t1=30371.41 microseconds. Finaly, dividing by a pixel sample rate equal to 9.611 microseconds, the result is 3160 pixels (the theorical middle line).
20	19	2	unsignedShort (B)	Time error from midscan to line end or second half scan error (SHSERR). The time error in clock counts from nominal midscan to line stop count of 161,165 can be converted to time error in microseconds by multiplying by R=1/(DataRate/16). The active scan time can be computed using the following formula ((161,164 + 161,165) - (Field 17 + Field 18)) * R. Since pixels for each detector within a line are sampled every 9.611 microseconds. The line length is given by (Active Scan Time)/9.611. Both scan error fields are comprised of a sign bit and 11 binary weighted bits, most significant bit first. Negative magnitudes (sign=1) are two's complement. When scan mirror assembly operates on scan angle monitors mode, three optical sensors give feedback to keep the first half and the second half scans as identical as possible. FHSERR and SHSERR result from this process.
21	21	4	unsignedInt (B)	Scan line direction. It is set to 0 for the forward scan and to 1 for the reverse scan.
22	25	4	unsignedInt (B)	Current scan line length. This is the number of scene pixels following the left fill pixels.

Satellite time code at start of scan				
23	29	1	unsignedByte (B)	Hundreds of days. Part of the satellite time code at start of scan. Same values on the corresponding calibration and supplemental records. In fact satellite time code is computed at the beginning of each new scan line and inserted after the Line Sync Code (MinorFrame 0).
23	30	1	unsignedByte (B)	Tens of days, days.
23	31	1	unsignedByte (B)	Tens of hours, hours.
23	32	1	unsignedByte (B)	Tens of minutes, minutes.
23	33	1	unsignedByte (B)	Tens of seconds, seconds.
23	34	1	unsignedByte (B)	Tenths of seconds, hundreths of seconds.
23	35	1	unsignedByte (B)	Milliseconds, tenths of milliseconds.
23	36	1	unsignedByte (B)	Hundredths of milliseconds, thousandths of milliseconds.
24	37	1	unsignedByte (B)	Information related to Inflight calibration: Detector identification. The detector numbering sequence within each spectral band is 1 thru 16, where detector 16 is the most notherly.
25	38	1	unsignedByte (B)	Not used (set to 0).
26	39	1	unsignedByte (B)	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	40	1	unsignedByte (B)	Calibration state sequence number. Each calibration lamp state lasts for 40 scans. This fields 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	41	4	unsignedInt (B)	Low level calibration value (thousandths of levels). For band 1 through 5 and 7, this is the zero-radiance calibration level which is output during the shutter-closed period. For thermal band, this is the detector-measured temperature of the shutter surface during the dc-restore calibration period.
29	45	4	unsignedInt (B)	High level calibration value (thousandths of levels). For band 1 through 5 and 7, this is the average over thirty contiguous pixels in the centre of the calibration wedge. For thermal band, this is 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	49	4	unsignedInt (B)	Calibration lamp computed gain value (millionths of units).
31	53	4	unsignedInt (B)	Calibration lamp computed bias value (millionths of units).
32	57	4	unsignedInt (B)	Applied gain value in millionths of units.
33	61	4	unsignedInt (B)	Applied bias value (milliontnths of units). The gain and biais values are stored as two's complement binary values in millionths of units. Fields 30 and 31 are the computed gain and biais using either onboard calibration device or default values. Fields 32 and 33 are the final gain and biais applied to the data from the specified detector.
34	65	4	string (B)	Local use. This field is designated as a local use area where all fields should be recorded in binary.

Chapter 3.4 Trailer File

3.4.1 Overview

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 that 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.

Each trailer file contains the following records:

- File descriptor record
- Trailer records

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.

3.4.2 File Descriptor Record

A detailed definition of the file descriptor record fixed segment is given in the "Standard Family" chapter and is repeated here below.

The length of this record is 4320 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	12	string (A)	Control document number for this data file.
10	29	2	short (A)	Control document revision number.
11	31	2	string (A)	File design descriptor revision letter.
12	33	12	string (A)	Software release number.
13	45	4	int (A)	File number.
14	49	16	string (A)	File name.
15	65	4	string (A)	Record sequence and location type flag.
16	69	8	int (A)	Sequence number location.

17	77	4	int (A)	Sequence number field length.
18	81	4	string (A)	Record code and location type flag.
19	85	8	int (A)	Record code location.
20	93	4	int (A)	Record code field length.
21	97	4	string (A)	Record length and location type flag.
22	101	8	int (A)	Record length location.
23	109	4	int (A)	Record length field length.
24	113	1	string (A)	Flag indicating that data interpretation information within file descriptor record. Value Y or N for Yes or No.
25	114	1	string (A)	Flag indicating that data interpretation information is included within the file in record(s) other than the descriptor record. Value Y or N for Yes or No.
26	115	1	string (A)	Flag indicating that data display information is included within file descriptor record Value Y or N for Yes or No.
27	116	1	string (A)	Flag indicating that data display information is included within the file in record(s) other than the file descriptor. Value Y or N for Yes or No.
28	117	64	string (B)	Reserved.
29	181	6	int (A)	Number of trailer record.
30	187	6	int (A)	Trailer record length.
31	193	24	string (B)	Reserved.
32	217	16	string (A)	Parity error count field locator.
33	233	16	string (A)	Quality code summary map field locator.
34	249	4072	string (A)	Blanks.

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 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

3.4.3 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 (eight records for PAN band). Each trailer record contains raw data histograms for 4 detectors for that band. The histogram is computed using 1 pixels on 10. In addition, it contains the parity error count and a quality summary.

The length of this record is 4320 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	4	int (A)	Trailer record sequence number.
8	17	4	int (A)	Sequence number of trailer record within band - Since one record of 4320 bytes can hold the histograms of only 4 detectors, for trailer records are required for each mirror scan direction of each spectral band. For band 6, full scans are replicated four times. Hence 16 histograms will be provided for each mirror scan direction of band 6.
9	21	4096	string (B)	Histograms for 4 detectors within the band - This fields contains the histogram of the raw image area for 4 detectors of the band. Histogram descibes gray levels repartition, thus one gray level (between 0 and 255) is associated with his number of occurences on image data. So, 4 trailer records are necessary to cover the 16 detectors of the band 1 through 5 and 7, 8 trailer records for band 8 and 2 trailer records for band 6. Histogram computation is made by step of 10 pixels in order to speed up processing without loosing meaningful information.
10	4117	4	int (A)	Parity errors count.
11	4121	200	string (B)	Quality summary, and local use - this field may be used for a free format description of the data quality.

Part

4

Chapter 4.1 Volume Directory File

4.1.1 Overview

The Supplemental Logical Volume contains two files:

- Volume Directory File
- Supplemental Data File

The only file class used in the ESA TM Supplemental logical volume is SUPPLEMENTAL FILE, with the corresponding four-character class code, SUPP.

This file (VDF) is part of the standard family. A detailed definition is given in the "Standard Family" chapter and repeated here below.

4.1.2 Volume Descriptor Record

The table below details the structure of the Volume Descriptor Record. Fields 1 to 6 are binary encoded. All others fields are in ASCII. Alphanumeric character strings are by default left-justified and numeric character strings are right-justified. Any unused field is filled with ASCII blanks. Number which does not fill the field are padded with leading blanks.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	12	string (A)	Superstructure format control document identifier.
10	29	2	string (A)	Superstructure control document revision number. It indicates the revision number or letter of the Superstrucure Format Control Document. Coded $C, for the original draft.
11	31	2	string (A)	Superstucture record format revision letter. It indicates the revision letter of the Superstrucure records 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 Superstructure 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	33	12	string (A)	Superstructure software release number. It identifies the software revision used to write this logical volume.
Logical volume id				
13	45	3	string (A)	'MNS': Mission, Number and Sensor type (e.g. 'L7E' for Landsat 7 ETM). Part of the logical volume identifier.
13	48	2	short (A)	'YY': Year of acquisition

13	50	3	int (A)	'DDD': Day of acquisition
13	53	3	int (A)	'PPP': Path in WRS
13	56	3	int (A)	'RRR': Row in WRS
13	59	2	string (A)	'AA': Acquisition station identifier.
Physical volume id				
14	61	2	string (A)	'AA': Processing station identifier. Part of the physical volume identifier.
14	63	1	string (A)	'Q': Quadrant number.
14	64	2	short (A)	'YY': Year of product generation.
14	66	3	int (A)	'DDD': Day of product generation.
14	69	6	dateTime (A)	'HHMMSS': Hour, minute and second of product generation.
14	75	1	byte (A)	'N': The CCT or Exabyte sequence number.
14	76	1	byte (A)	'n': The number of CCTs or exabytes generated for current product.
Volume set id				
15	77	8	string (A)	Satellite name. Part of the volume set identifier.
15	85	1	string (A)	Satellite number.
15	86	7	string (A)	Instrument.
16	93	2	short (A)	Number of physical volumes in the set. It indicates the total number of Physical volume in a Volume Set. A blank field indicates that the information is was not avalaible at the time the Logical Volume was recorded.
17	95	2	short (A)	Physical volume number, start of logical volume. This field indicates the sequence number of the Physical volume within a volume set, which contains the 1st record of the Logical Volume.
18	97	2	short (A)	Physical volume number, end of logical volume. 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.
19	99	2	short (A)	Physical volume sequence number (i.e of current tape) - 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 for field 17. The value in this field must lie within 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).
20	101	4	int (A)	First referenced file number in this physical volume. 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 number count.
21	105	4	int (A)	Logical volume number within volume set. 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	109	4	int (A)	Logical volume number within physical volume. This is the sequence number of the present Logical Volume within a Physical Volume.
23	113	8	dateTime (A)	Logical volume creation date (Generation date reference field). It indicates the date when the Logical Volume was recorded. The format is "YYYYMMDD", where YYYY is the year, MM the month and DD the day.
24	121	8	dateTime (A)	Logical volume creation time (Generation time reference field). It indicates the time when the Logical Volume was recorded. The form of the code is "HHMMSSXX", where HH is the hour, MM the minute, SS the second and XX is hundredths of seconds.
25	129	12	string (A)	Logical volume generating country. It indicates the name of the country generating this logical volume.

26	141	8	string (A)	Logical volume generating agency. It indicates the laboratory or the center generating this logical volume.
27	149	12	string (A)	Logical volume generating facility. It indicates the computer facility on which the logical volume was recorded.
28	161	4	int (A)	Number of pointer records in this volume directory. This gives the number of data files in the logical volume.
29	165	4	int (A)	Total number of records this in volume directory. This is the number of File pointers records plus one (for this record), plus the number of Text Records.
30	169	4	int (A)	Number of logical volumes in the set.
31	173	88	string (B)	Spare segment. Reserved for future revisions of this record format.
32	261	100	string (B)	Local use segment. When unused this field is filled with blanks.

4.1.3 File Pointer Record

The table below details the structure of the File Pointer Record. Fields 1 to 6 are binary encoded. All others fields are in ASCII. Alphanumeric character strings are by default left-justified and numeric character strings are right-justified. Any unused field is filled with ASCII blanks. Number which does not fill the field are padded with leading blanks.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	4	int (A)	Referenced file number. Sequence number within the Logical Volume of the file referenced by this pointer. This is also the sequence number of the File Pointer within the Volume Directory. The first file following the first Volume Directory (2nd file of the Logical Volume).
Referenced file name				
10	21	6	string (A)	Satellite name. Part of the referenced file name, which is the unique identification provided when the volume directory is created in order to specify the file referenced by this pointer.
10	27	2	short (A)	Correction level.
10	29	4	string (A)	File name.
10	33	3	string (A)	Interleaving indicator. (e.g. 'BSQ').
10	36	1	byte (A)	Band number associated to file name.
11	37	28	string (A)	Referenced file class. This is a description of the class to which the referenced file belongs. The class of a file is based on the nature of its content.
12	65	4	string (A)	Referenced file class code. The 4-character code for the class described in the

				previous field.
13	69	28	string (A)	Referenced file data type. This field indicates the data type contained in the referenced file.
14	97	4	string (A)	Referenced file data type code. The 4-character code for the data type described in the previous field.
15	101	8	int (A)	Number of records in the referenced file. If this number is unknown at the creation time, the field is left blank.
16	109	8	int (A)	Referenced file descriptor record length. This field gives 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	117	8	int (A)	Referenced file maximun record length. This field gives the length in bytes of the longest record other than the File Descriptor Record in the referenced file.
18	125	12	string (A)	Referenced file length type. This field gives the length type of the file records. For this format, fixed length records are used, so this field contains 'FIXED$LENGTH'.
19	137	4	string (A)	Referenced file length type code. The 4-character code for the record length type described in the previous field. For this format, the value is 'FIXD'.
20	141	2	short (A)	Referenced file physical volume, start of file. This field indicates the sequence number of the Physical volume which contains the 1st record of the referenced file. The field is left blank if information was unknown at the time of recording.
21	143	2	short (A)	Referenced file physical volume, end of file. This field indicates the sequence number of the Physical volume which contains the last record of the referenced file. The field is left blank if information was unknown at the time of recording.
22	145	8	int (A)	Referenced file portion, 1st record number. When a portion of the referenced file is on the PREVIOUS physical volume, this number is the one of the first record of the referenced file to be recorded on THIS physical volume. In all other conditions this number is set to 1. This field and the next one are the only fields in the file pointer record to be changed on a repeated volume directory. They are only changed in the file pointer record that refers to the split file.
23	153	8	int (A)	Referenced file portion, last record number. When a portion of the referenced file is on the NEXT physical volume, this number is the one of the last record of the referenced file to be recorded on THIS physical volume. See previous field for more detailed explanations.
24	161	100	string (B)	Spare segment. Reserved for future revisions of this record format.
25	261	100	string (B)	Local use segment. When unused this field is filled with blanks.

4.1.4 Text Record

The table below details the structure of the Text Record. Fields 1 to 6 are binary encoded. All others fields are in ASCII. Alphanumeric character strings are by default left-justified and numeric character strings are right-justified. Any unused field is filled with ASCII blanks. Number which does not fill the field are padded with leading blanks.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).

7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	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$.
9	17	50	string (A)	Supplemental file description - For Landsat 7, LANDSAT7ENHAN.$THEM.$MAP.$SUPPL.$DATA$FILE $$$$$$. And LANDSAT$"S"$THEMATIC$MAPPER$SUPPLEMENTAL$DATA$FILE$$. Where "S" is the number of the other Landsat missions.
product_creation				
10	67	39	string (A)	Location of product creation - PROCESSED:$"CC~SSSSSS"$FOR$ESA-ESRIN$$$$ON$ "CC~SSSSSS"(Country Code~Station Code): {GER~NEUSTR,ITA~FUCINO,SWE~KIRUNA,SPA~MASPAL}.
10	106	19	dateTime (A)	Date of product creation - "YYYYMMDD", where "YYYYY" is the year, "MM" is the month and "DD" is the day.
Orbit identification				
11	125	39	string (A)	Orbit identification - Text. The orbit is 8-byte ASCII numeric string.
11	164	10	dateTime (A)	Date of recording of the original image. Same format as field 10.
12	174	43	string (A)	Physical tape identification - TAPE$ID:$$"XXNNNN"$$$$$$$$$$$TAPE$"MM"$OF$"LL"$$, 16 character field followed by the tape sequence number, "MM", within the physical volume set containing a total of "LL" tapes.
13	217	144	string (A)	Blanks

Chapter 4.2 Supplemental File

4.2.1 Overview

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 contain the following records:

- File descriptor record
- Interval header record
- TM housekeeping data record
- Ephemeris and attitude data record
- Raw jitter measurements 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. 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).

4.2.2 File Descriptor Record

A detailed definition of the file descriptor record fixed segment is given in the "Standard Family" chapter and is repeated here below.

The length of this record is 540 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	12	string (A)	Control document number.
10	29	2	short (A)	Control document revision number.
11	31	2	string (A)	Superstructure record format revision letter.
12	33	12	string (A)	Software release number - TMFR-VRX.X.X; where X.X.X is the software version.
13	45	4	int (A)	File number.
14	49	16	string (A)	File name - LS{4,5,7}{~TM,ETM}"NN"SUPP$$$, where "NN" is the level of correction applied.

15	65	4	string (A)	Record sequence and location type flag.
16	69	8	int (A)	Sequence number location.
17	77	4	int (A)	Sequence number field length.
18	81	4	string (A)	Record code and location type flag.
19	85	8	int (A)	Record code location.
20	93	4	int (A)	Record code field length.
21	97	4	string (A)	Record length and location type flag.
22	101	8	int (A)	Record length location.
23	109	4	int (A)	Record length field length.
24	113	1	string (A)	Flag indicating that data interpretation information is included within the file descriptor record.
25	114	1	string (A)	Flag indicating that data interpretation information is included within the file in record(s) other than the descriptor.
26	115	1	string (A)	Flag indicating that data display information is included within the file descriptor record.
27	116	1	string (A)	Flag indicating that data display information is included within the file other than the descriptor.
28	117	64	string (B)	Reserved segment.
29	181	6	int (A)	Number of interval-related header records.
30	187	6	int (A)	Interval-related header record length.
31	193	6	int (A)	Number of TM housekeeping data records.
32	199	6	int (A)	TM housekeeping data record length.
33	205	6	int (A)	Number of processed ephemeris data records.
34	211	6	int (A)	Processed ephemeris data record length.
35	217	6	int (A)	Number of scene definition (scene header) records.
36	223	6	int (A)	Scene definition record length.
37	229	6	int (A)	Number of scene quality data records.
38	235	6	int (A)	Scene quality data record length.
39	241	6	int (A)	Number of geometric modelling (map projection) data records.
40	247	6	int (A)	Geometric modelling data record length.
41	253	6	int (A)	Number of sparse matrices records.
42	259	6	int (A)	Sparse matrices record length.
43	265	6	int (A)	Number of GCD mirror scan start time records.
44	271	6	int (A)	GCD mirror scan start time record length.
45	277	6	int (A)	Number of high frequency along scan matrix records.
46	283	6	int (A)	High frequency along scan matrix record length.
47	289	6	int (A)	Number of high frequency cross scan matrix records;
48	295	6	int (A)	High frequency cross scan matrix record length;
49	301	6	int (A)	Number of annotation records.
50	307	6	int (A)	Annotation record length.
51	313	6	int (A)	Number of mission telemetry ancillary records.

52	319	6	int (A)	Mission telemetry ancillary record length.
53	325	6	int (A)	Number of local use records.
54	331	6	int (A)	Local use record length.
55	337	16	string (A)	Interval data start time locator.
56	353	16	string (A)	Interval data stop time locator.
57	369	16	string (A)	Orbit field locator.
58	385	156	string (A)	Spare (Blanks).

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

4.2.3 Interval Header Record

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

The length of this record is 1800 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Sequence number.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	4	int (A)	Interval header record sequence number.
8	17	4	string (A)	Blanks.
9	21	4	string (A)	Blanks.
Input scene start time				
10	25	4	int (A)	Input scene start time - day of the year (DDD). Fields 10 and 11 may be blank filled if there is no associated imagery volume.
10	29	8	int (A)	Input scene start time - milliseconds of the day (MMMMMMMM).
10	37	3	int (A)	Input scene start time - thousandths of milliseconds of day (TTT). Fields 10 and 11

				may be blank filled if there is no associated imagery volume.
10	40	1	string (A)	Input scene start time - Blank
Input scene stop time				
11	41	4	int (A)	Input scene stop time - day of the year
11	45	8	int (A)	Input scene stop time - milliseconds of the day
11	53	3	int (A)	Input scene stop time - thousandths of milliseconds of the day
11	56	1	string (A)	Input scene stop time - Blank
PCD telemetry start time				
12	57	4	int (A)	PCD telemetry start time - day of the year
12	61	8	int (A)	PCD telemetry start time - milliseconds of the day.
12	69	3	int (A)	PCD telemetry start time - thousandths of millisecond of the day.
12	72	1	string (A)	PCD telemetry start time - Blank.
PCD telemetry stop time				
13	73	4	int (A)	PCD telemetry stop time - day of the year.
13	77	8	int (A)	PCD telemetry stop time - milliseconds of the day.
13	85	3	int (A)	PCD telemetry stop time - thousandths of millisecond of the day.
13	88	1	string (A)	PCD telemetry stop time - Blank.
14	89	4	int (A)	Number of PCD major frames.
15	93	8	int (A)	Orbit number.
16	101	1700	string (B)	Spare.

4.2.4 TM Housekeeping Data Ancillary Record

Each Landsat housekeeping data record contains all the information required to interpret thirty two elements from the 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 housekeeping telemetry data in a set of four PCD major frames, there will be only one housekeeping data record for every 16.384 seconds of imagery data. The number of houskeeping records depends upon product size varying from one to a maximum of three for the full scene.

The length of this record is 2880 bytes.

- **Telemetry function:** Fields 15 through 20 contain TM housekeeping telemetry conversion coefficients A0, A1, A2, A3, A4 and A5 espectively, which are required to convert the housekeeping telemetry data from counts (C) to Engineering Units (EU). Form of the telemetry function is the following one: EU=A0 + A1*C + A2*C*C + A3*C*C*C + A4*C*C*C*C + A5*C*C*C *C*C.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Sequence number.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code.

6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	4	int (A)	TM housekeeping data record sequence number. This fields contains the sequence number of this ancillary record within the set of interval related ancillary records of this type, starting from 1.
8	17	4	int (A)	PCD major Frame identifier - This TM housekeeping ancillary record has been defined for telemetry data which is stored in the third PCD major frame after the telemetry major frame
Start of PCD major frame				
9	21	4	int (A)	Day of year at start of PCD frame (Satellite Time Code (STC). This code represents the start time for PCD major frame and provides the timing reference for all data in the PCD cycle.
10	25	8	int (A)	Milliseconds of day at start of PCD frame (STC).
11	33	3	int (A)	Thousandths of milliseconds of day at start of PCD frame (STC).
12	36	1	string (B)	Blank.
Blackbody temperature, degree C				
13	37	10	int (A)	TM housekeepinng sample time offset (microseconds).
14	47	4	int (A)	TM housekeeping sample
15	51	12	float (A)	A0 coefficient.
16	63	12	float (A)	A1 coefficient.
17	75	12	float (A)	A2 coefficient
18	87	12	float (A)	A3 coefficient
19	99	12	float (A)	A4 coefficient
20	111	12	float (A)	A5 coefficient
Silicon Focal Plane Asembly (FPA) temperature, degrees C				
21	123	86	string (B)	Constructed as group of fields 13:20.
Calibration shutter temperaure, degrees C				
22	209	86	string (B)	Constructed as group of fields 13:20.
23	295	86	string (B)	Unused
Baffle temperaure, degrees C				
24	381	86	string (B)	Constructed as group of fields 13:20.
Cold FPA temperature, degrees C				
25	467	86	string (B)	Constructed as group of fields 13:20.
26	553	86	string (B)	Unused
27	639	86	string (B)	Unused
Scan line corrector temperaure, degrees C				
28	725	86	string (B)	Constructed as group of fields 13:20.
Calibration shutter hub temperature, degrees C				
29	811	86	string (B)	Constructed as group of fields 13:20.

30	897	86	string (B)	Unused
31	983	86	string (B)	Unused
Relay optics temperaure, degrees C				
32	1069	86	string (B)	Constructed as group of fields 13:20.
33	1155	86	string (B)	Unused
34	1241	86	string (B)	Unused
35	1327	86	string (B)	Unused
36	1413	86	string (B)	Unused (Unpacked as serial word B)
37	1499	86	string (B)	Unused
38	1585	86	string (B)	Unused (Unpacked as serial word D)
39	1671	86	string (B)	Unused (Unpacked as serial word E)
40	1757	86	string (B)	Unused (Unpacked as serial word F)
41	1843	86	string (B)	Unused (Unpacked as serial word G)
42	1929	86	string (B)	Unused
43	2015	86	string (B)	Unused (Unpacked as serial word L)
Primary mirror temperature, degrees C				
44	2101	86	string (B)	Constructed as group of fields 13:20.
45	2187	86	string (B)	Unused
Secondary mirror temperature, degrees C				
46	2273	86	string (B)	Constructed as group of fields 13:20.
47	2359	86	string (B)	Unused
48	2445	86	string (B)	Unused
49	2531	86	string (B)	Unused
50	2617	86	string (B)	Unused
51	2703	86	string (B)	Unused
52	2789	48	string (A)	Serial Words B,D,E,F,G,L. The content of serial words B,D,E,F,G and L extracted from minor frame number 32,34,35,36,37 and 39 is reproduced here in an expanded form, with byte being used to store the data from each bite of the serial word. Each byte can take an ASCII numeric value of 0 (OFF) or 1(ON).
53	2837	44	string (B)	Spare

4.2.5 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. The number of ephemeris and attitude data ancillary records depends upon product size with a maximum of six records required to span one full scene of TM video data. 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.

The length of this record is 4680 bytes.

Just here below, is remind unit convention and coordinate system used for describing ephemeris and attitude ancillary data such as expressed in the format.

- **Units and frame of reference:** All components are stored with reference to the earth-centred inertial (ECI) frame. In the ECI True Of Date (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 (from field number 14 up to field number 16)are given in ECITOD coordinates in metres. Spacecraft velocity components (from field number 17 up to field number 19) are given in metres/millisecond.
- **Attitude data:** Euler parameters EPA1, EPA2, EPA3 and EPA4 (from field number 21 up to field number 24) are PCD attitude quaternions (propagated from gyro data) that estimate the Attitude Control System (ACS) reference axis (spacecraft axis) with respect to the ECITOD system. Components 1 through 3 define the Eigen axis of the rotation in the ECI coordinates, and the fourth component defines rotation about the Eigen axis as follow:

  EPA1 = AX * sin(O/2)

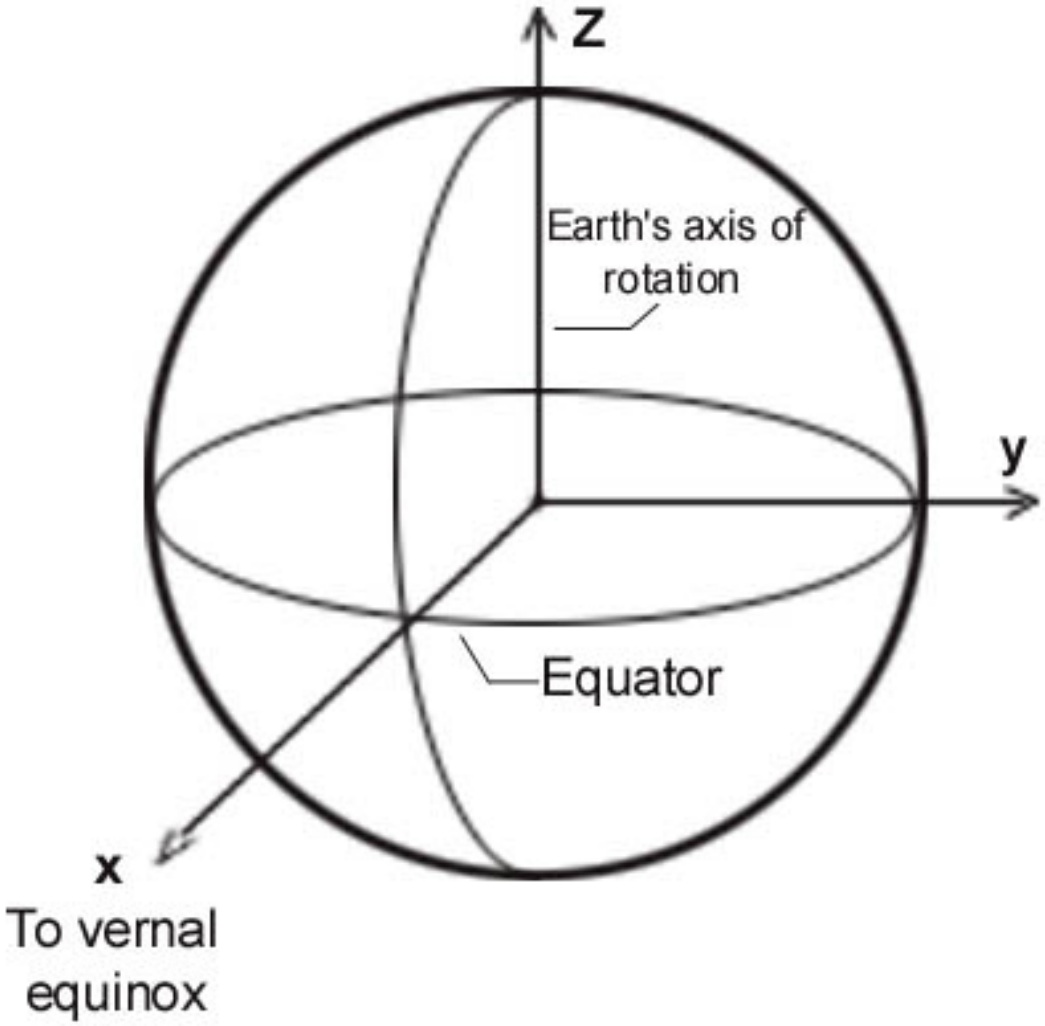
  EPA2 = AY * sin(O/2)

  EPA3 = AZ * sin(O/2)

  EPA4 = cos(O/2)

  where A is the Eigen axis of rotation, and O is the rotation angle about the Eigen Axis which define the ACS reference axis.

  Quaternion estimates include information from Star trackers, Gyros and Gyro drift estimate. Quartenion estimates are used for building direction cosines matrix required for transformatiom from ACS reference axes to orbital coordinate system into which is expressed the roll, pitch and yaw variations.



ECI coordinate system

- **Gyro data:** Gyro data and gyro drift data are calulated in the ACS reference axis coordinate system. Gyro drift should be substracted from gyro data as a correction for computing spacecraft attitude.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Sequence number
2	5	1	unsignedByte (B)	1st record sub-type code
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code
5	8	1	unsignedByte (B)	3rd record sub-type code
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	4	int (A)	Ephemeris and lattitude data record sequence number
Four flags indicating whether component was updated				
8	17	1	byte (A)	Ephemeris flag. Part of the four flags indicating whether component was updated in the current PCD major frame. Values are 0/1 representing NO/YES. Ephemeris flag is

				updated in alternate major frame.
8	18	1	byte (A)	Attitude flag. Attitude data is updated in every major frame.
8	19	1	byte (A)	Gyro flag. Gyro data is updated 64 times in every major frame at equal time intervals.
8	20	1	byte (A)	Gyro drift flag. Gyro drift data is updated once in approximately every sixteenth major frame.
Start of PCD major frame				
9	21	4	int (A)	Day of year at start of PCD frame (STC).
10	25	8	int (A)	Milliseconds of day at start of PCD frame (STC).
11	33	3	int (A)	Thousandths of milliseconds of day at start of PCD frame (STC)
12	36	1	string (B)	Blank
13	37	10	int (A)	Ephemeris measurement time offset (microseconds). Delay due to time required by flight software to acumulate the telemetry and transfer it to the instrument for insertion into the PCD frame. This delay is -4.06 seconds for TM and -8.196 seconds for TM.
14	47	22	double (A)	Spacecraft position component X
15	69	22	double (A)	Spacecraft position component Y
16	91	22	double (A)	Spacecraft position component Z
17	113	22	double (A)	Spacecraft velocity component X. Output unit is meter/millisecond.
18	135	22	double (A)	Spacecraft velocity component Y. Output unit is meter/millisecond.
19	157	22	double (A)	Spacecraft velocity component Z. Output unit is meter/millisecond.
20	179	10	int (A)	Attitude measurement time offset (microseconds). Delay due to time required by flight software to acumulate the telemetry and transfer it to the instrument for insertion into the PCD frame. This delay is -4.06 seconds for TM and -8.196 seconds for ETM+.
21	189	22	double (A)	EPA1 - first quaterniom.
22	211	22	double (A)	EPA2 - second quaternion.
23	233	22	double (A)	EPA3 - third quaterniom.
24	255	22	double (A)	EPA4 - fourth quaternion.
25	277	10	int (A)	Gyro measurement (first measurement) time offset (microseconds). Time of measurement of gyro drift is indeterminate. For TM, gyro measurement time offset is equal to -0.028 second. For ETM+, no delay is applied because values are inserted in realtime into PCD frame.
26	287	66 x64	double (A)	64 (3*22) sets of gyro measurements, where each sets consist of measurements for each of the three axis. Gyro ouput units are arc-seconds of angle.
27	4511	10	int (A)	Gyro drift measurement time offset (microseconds). For TM the time offset is -8,192 seconds for TM and -14.337 seconds for TM.
28	4521	22	double (A)	Gyro drift - x axis. Gyro drift output unit is radians/512 msecs.
29	4543	22	double (A)	Gyro drift - y axis. Gyro drift output unit is radians/512 msecs.
30	4565	22	double (A)	Gyro drift - z axis. Gyro drift output unit is radians/512 msecs.
31	4587	94	string (B)	Spare

4.2.6 Raw Jitter Measurements Ancillary Record

Each raw jitter measurements ancillary record contains all the information obtained from the three nominally orthogonal Angular Displacement Sensors (ADS). The ASDA is mounted on the TM/ETM+ telescope. The number of raw jitter measurements ancillary records depends upon product size with a maximum of twelve records required to span one full scene of TM video data The ADS has been designed to measure the magnitude of the jitter in the nominal frequency

range 2 to 125 Hz.

The length of this record is 6300 bytes.

- **Angular Displacement sensor temperature:** Four ASDA temperature measurements are sampled one per PCD major. Measurements are given in Degrees Celisus unit, coded in ASCII float (12 bytes), miminum temperature is 0 and maximun 50.
- **Angular Displacement Senor measurement:** Measurements are provided on an half of one PCD major frame basis (one PCD major frame occupies a time period of 4.096 secs). Digital count 0 is maximum positive angular displacement, and digital count 4075 is maximum negative angular displacement. The nominal zero angular displacement output of the ASDA is 2048 +/- 50 (variation of 50 counts is considered to be of negligible magnitude).
- **Time offset:** Fields 21,22,23 give the time offset of the observation since the start of the major frame, in micorseconds. Since there are measurements for 3 ADS axis, the time offset is provided for the first measurement of each of the three axis. The time interval between succesive measurements is 2 milliseconds.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Sequence number.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	4	int (A)	Raw jitter measurement record sequence number within the set interval related ancillary record type.
8	17	4	int (A)	Sequence number within PCD major frame.
Start of PCD major frame				
9	21	4	int (A)	Day of year at start of PCD frame (STC)
10	25	8	int (A)	Milliseconds of day at start of PCD frame (STC)
11	33	3	int (A)	Thousandths of milliseconds at start of PCD frame (STC)
12	36	1	string (B)	Blank
13	37	10	int (A)	ADS temperature (1) time offset (microseconds)
14	47	12	float (A)	ADS temperature (1) Degrees C
15	59	10	int (A)	ADS temperature (2) time offset (microseconds)
16	69	12	float (A)	ADS temperature (2) Degrees C
17	81	10	int (A)	ADS temperature (3) time offset (microseconds)
18	91	12	float (A)	ADS temperature (3) Degrees C
19	103	10	int (A)	ADS temperature (4) time offset (microseconds)
20	113	12	float (A)	ADS temperature (4) Degrees C
21	125	10	int (A)	ADS measurement (1),axis 1,time offset (microseconds)
22	135	10	int (A)	ADS measurement (1),axis 2,time offset (microseconds)
23	145	10	int (A)	ADS measurement (1),axis 3,time offset (microseconds)
24	155	6	short (B)	ADS measurements, each jitter measurements ancillary record contains 1024 ADS

		x1024		measurement samples. One sample consists of three measurements. Measurements are respectively related to the roll, pitch, yaw axis. They are stored as a 2 bytes binary integer where the least signicant bit represent $250/2^{11}$ microradians. Finaly, for one PCD major frame, 2048 ADS measurement samples are given.
25	6299	1	string (B)	Spare

Part

5

Calibration Logical Volume

Chapter 5.1 Volume Directory File

5.1.1 Overview

The Calibration Logical Volume has been designed by ESA-ESRIN to supply the calibration data acquired from the Landsat satellites within the Landsat data stream. The Calibration Logical Volume is included in the standard ESA-ESRIN Landsat products. The Calibration Logical Volume takes place 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:

- Volume Directory File
- Calibration Data File

The file class used in the Landsat 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.

This file (VDF) is part of the standard family. A detailed definition is given in the "Standard Family" chapter and repeated here below.

5.1.2 Volume Descriptor Record

The table below details the structure of the Volume Descriptor Record. Fields 1 to 6 are binary encoded. All others fields are in ASCII. Alphanumeric character strings are by default left-justified and numeric character strings are right-justified. Any unused field is filled with ASCII blanks. Number which does not fill the field are padded with leading blanks.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	12	string (A)	Superstructure format control document identifier.
10	29	2	string (A)	Superstructure control document revision number. It indicates the revision number or letter of the Superstrucure Format Control Document. Coded $C, for the original draft.
11	31	2	string (A)	Superstucture record format revision letter. It indicates the revision letter of the Superstrucure records 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 Superstructure 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	33	12	string (A)	Superstructure software release number. It identifies the software revision used to write this logical volume.

Logical volume id				
13	45	3	string (A)	'MNS': Mission, Number and Sensor type (e.g. 'L7E' for Landsat 7 ETM). Part of the logical volume identifier.
13	48	2	short (A)	'YY': Year of acquisition
13	50	3	int (A)	'DDD': Day of acquisition
13	53	3	int (A)	'PPP': Path in WRS
13	56	3	int (A)	'RRR': Row in WRS
13	59	2	string (A)	'AA': Acquisition station identifier.
Physical volume id				
14	61	2	string (A)	'AA': Processing station identifier. Part of the physical volume identifier.
14	63	1	string (A)	'Q': Quadrant number.
14	64	2	short (A)	'YY': Year of product generation.
14	66	3	int (A)	'DDD': Day of product generation.
14	69	6	dateTime (A)	'HHMMSS': Hour, minute and second of product generation.
14	75	1	byte (A)	'N': The CCT or Exabyte sequence number.
14	76	1	byte (A)	'n': The number of CCTs or exabytes generated for current product.
Volume set id				
15	77	8	string (A)	Satellite name. Part of the volume set identifier.
15	85	1	string (A)	Satellite number.
15	86	7	string (A)	Instrument.
16	93	2	short (A)	Number of physical volumes in the set. It indicates the total number of Physical volume in a Volume Set. A blank field indicates that the information is was not avalaible at the time the Logical Volume was recorded.
17	95	2	short (A)	Physical volume number, start of logical volume. This field indicates the sequence number of the Physical volume within a volume set, which contains the 1st record of the Logical Volume.
18	97	2	short (A)	Physical volume number, end of logical volume. 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.
19	99	2	short (A)	Physical volume sequence number (i.e of current tape) - 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 for field 17. The value in this field must lie within 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).
20	101	4	int (A)	First referenced file number in this physical volume. 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 number count.
21	105	4	int (A)	Logical volume number within volume set. 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	109	4	int (A)	Logical volume number within physical volume. This is the sequence number of the present Logical Volume within a Physical Volume.
23	113	8	dateTime (A)	Logical volume creation date (Generation date reference field). It indicates the date when the Logical Volume was recorded. The format is "YYYYMMDD", where YYYY is the year, MM the month and DD the day.

24	121	8	dateTime (A)	Logical volume creation time (Generation time reference field). It indicates the time when the Logical Volume was recorded. The form of the code is "HHMMSSXX", where HH is the hour, MM the minute, SS the second and XX is hundredths of seconds.
25	129	12	string (A)	Logical volume generating country. It indicates the name of the country generating this logical volume.
26	141	8	string (A)	Logical volume generating agency. It indicates the laboratory or the center generating this logical volume.
27	149	12	string (A)	Logical volume generating facility. It indicates the computer facility on which the logical volume was recorded.
28	161	4	int (A)	Number of pointer records in this volume directory. This gives the number of data files in the logical volume.
29	165	4	int (A)	Total number of records this in volume directory. This is the number of File pointers records plus one (for this record), plus the number of Text Records.
30	169	4	int (A)	Number of logical volumes in the set.
31	173	88	string (B)	Spare segment. Reserved for future revisions of this record format.
32	261	100	string (B)	Local use segment. When unused this field is filled with blanks.

5.1.3 File Pointer Record

The table below details the structure of the File Pointer Record. Fields 1 to 6 are binary encoded. All others fields are in ASCII. Alphanumeric character strings are by default left-justified and numeric character strings are right-justified. Any unused field is filled with ASCII blanks. Number which does not fill the field are padded with leading blanks.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	4	int (A)	Referenced file number. Sequence number within the Logical Volume of the file referenced by this pointer. This is also the sequence number of the File Pointer within the Volume Directory. The first file following the first Volume Directory (2nd file of the Logical Volume).
Referenced file name				
10	21	6	string (A)	Satellite name. Part of the referenced file name, which is the unique identification provided when the volume directory is created in order to specify the file referenced by this pointer.
10	27	2	short (A)	Correction level.
10	29	4	string (A)	File name.
10	33	3	string (A)	Interleaving indicator. (e.g. 'BSQ').

10	36	1	byte (A)	Band number associated to file name.
11	37	28	string (A)	Referenced file class. This is a description of the class to which the referenced file belongs. The class of a file is based on the nature of its content.
12	65	4	string (A)	Referenced file class code. The 4-character code for the class described in the previous field.
13	69	28	string (A)	Referenced file data type. This field indicates the data type contained in the referenced file.
14	97	4	string (A)	Referenced file data type code. The 4-character code for the data type described in the previous field.
15	101	8	int (A)	Number of records in the referenced file. If this number is unknown at the creation time, the field is left blank.
16	109	8	int (A)	Referenced file descriptor record length. This field gives 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	117	8	int (A)	Referenced file maximun record length. This field gives the length in bytes of the longest record other than the File Descriptor Record in the referenced file.
18	125	12	string (A)	Referenced file length type. This field gives the length type of the file records. For this format, fixed length records are used, so this field contains 'FIXED$LENGTH'.
19	137	4	string (A)	Referenced file length type code. The 4-character code for the record length type described in the previous field. For this format, the value is 'FIXD'.
20	141	2	short (A)	Referenced file physical volume, start of file. This field indicates the sequence number of the Physical volume which contains the 1st record of the referenced file. The field is left blank if information was unknown at the time of recording.
21	143	2	short (A)	Referenced file physical volume, end of file. This field indicates the sequence number of the Physical volume which contains the last record of the referenced file. The field is left blank if information was unknown at the time of recording.
22	145	8	int (A)	Referenced file portion, 1st record number. When a portion of the referenced file is on the PREVIOUS physical volume, this number is the one of the first record of the referenced file to be recorded on THIS physical volume. In all other conditions this number is set to 1. This field and the next one are the only fields in the file pointer record to be changed on a repeated volume directory. They are only changed in the file pointer record that refers to the split file.
23	153	8	int (A)	Referenced file portion, last record number. When a portion of the referenced file is on the NEXT physical volume, this number is the one of the last record of the referenced file to be recorded on THIS physical volume. See previous field for more detailed explanations.
24	161	100	string (B)	Spare segment. Reserved for future revisions of this record format.
25	261	100	string (B)	Local use segment. When unused this field is filled with blanks.

5.1.4 Text Record

The table below details the structure of the Text Record. Fields 1 to 6 are binary encoded. All others fields are in ASCII. Alphanumeric character strings are by default left-justified and numeric character strings are right-justified. Any unused field is filled with ASCII blanks. Number which does not fill the field are padded with leading blanks.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code
3	6	1	unsignedByte (B)	Record type code for superstructure records.

4	7	1	unsignedByte (B)	2nd record sub-type code
5	8	1	unsignedByte (B)	3rd record sub-type code
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Continuation flag
9	17	50	string (A)	Calibration file description
Product creation				
10	67	39	string (A)	Product creation - Location
10	106	19	dateTime (A)	Product creation - Date
11	125	49	string (A)	Image identification
12	174	54	string (A)	Physical tape identification
13	228	25	string (A)	Calibration Parameter File (CPF) used for product processing. USGS is reviewing TM/ETM+ CPF file on a monthly basis provide it to Landsat International Ground Station. Product acquisition date may belong to CPF file validity period. CPF file version is critical for TM product data acquited and processed in bumper mode. Signigicant swath shift may be noticed if geometry corretions are performed with a non updated mirror model parameters.
14	253	108	string (A)	Blanks

Chapter 5.2 Calibration File

5.2.1 Overview

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.

Calibration file, as used by ESA, contains 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 segment).

CEOS Landsat TM products include one calibration file describing calibration values for the seven bands.

CEOS Landsat ETM+ products include three calibration files; a first one is related to VNIR/SWIR and low gain thermal bands, the second one to panchromatic band and the third one to high gain thermal band.

5.2.2 File Descriptor Record

A detailed definition of the file descriptor record fixed segment is given in the "Standard Family" chapter and is repeated here below.

For products from TM, length of this record is 6090 bytes. For products from ETM+, length of the file descriptor record for VNIR/SWIR bands, thermal band in high gain mod, and panchromatic band is respectively 7182, 2012, 1026 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number
2	5	1	unsignedByte (B)	1st record sub-type code
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code
5	8	1	unsignedByte (B)	3rd record sub-type code
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	12	string (A)	Control document number for this data file format
10	29	2	short (A)	Control document revision number
11	31	2	string (A)	Superstructure record format revision letter
12	33	12	string (A)	Software release number
13	45	4	int (A)	File number
14	49	16	string (A)	File name
15	65	4	string (A)	Record sequence and location type flag

16	69	8	int (A)	Sequence number location
17	77	4	int (A)	Sequence number field length
18	81	4	string (A)	Record code and location type flag
19	85	8	int (A)	Record code location
20	93	4	int (A)	Record code field length
21	97	4	string (A)	Record length and location type flag
22	101	8	int (A)	Record length location
23	109	4	int (A)	Record length field length
24	113	1	string (A)	Flag about data interpretation on file descriptor record
25	114	1	string (A)	Flag about data interpretation on record
26	115	1	string (A)	Flag about data interpretation on other record
27	116	1	string (A)	Flag about data display information in file descriptor
28	117	4	int (A)	Mission number
29	121	4	int (A)	Path number
30	125	4	int (A)	Aquisition year
31	129	4	int (A)	Aquisition month
32	133	4	int (A)	Aquisition day
33	137	12	dateTime (A)	Aquisition start time
34	149	12	dateTime (A)	Aquisition stop time
35	161	4	int (A)	Number of acquired swath
36	165	4	int (A)	Number of physical records
37	169	4	int (A)	Physical record length
38	173	2	short (A)	Blocking factor
39	175	2	short (A)	Number of logical records
40	177	4	int (A)	Logical record length
41	181	40	string (A)	Blanks
42	221	4	int (A)	Record relative to first video
43	225	36	string (A)	Blanks
44	261	16	string (A)	Scan number field locator
45	277	16	string (A)	Band number field locator
46	293	16	string (A)	Detector number field locator
47	309	16	string (A)	Scan time field locator
48	325	16	string (A)	Record sequence number within physical record locator
49	341	16	string (A)	Scan direction field locator
50	357	4	string (A)	Blanks
51	361		string (A)	Blanks

Variable Segment

The calibration file variable segment gives the number and length of the calibration records in the calibration file. In

addition, locators are given, supplying the location and format of two important data fields within the calibration file. Locators for the calibration file are constructed from sixteen bytes in the same way used for imagery and suplemental files.

5.2.3 Calibration Data Record

Calibration data are records of the detector response to the calibration lamp radiance. For products data from TM, length of the calibration data record is 6090 bytes. For products data from ETM+, length of the calibration data record for VNIR/SWIR bands, thermal band in high gain mod, and panchromatic band is respectively 7182, 2012,1026 bytes. The first image data record is not related to the first calibration data record. Scan line relationship between the both records is done using the satellite time code.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record Sequence Number
2	5	1	unsignedByte (B)	First record sub-type code
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code
5	8	1	unsignedByte (B)	3rd record sub-type code
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	short (B)	Blocking factor (f). f=7 for standards seven TM/ETM+ bands, and f=1 for the high gain thermal band and the panchromatic band.
8	15	2	unsignedShort (B)	Length of logic record
9	17	2	unsignedShort (B)	Sequence number (file)
10	19	2	unsignedShort (B)	Sequence number (record)
11	21	2	short (B)	Scan number
12	23	2	short (B)	Scan direction
13	25	2	short (A)	Band number
14	27	2	short (A)	Detector number
Satellite time code at start of scan				
15	29	1	unsignedByte (B)	Hundreds of days. Part of the satellite time code at start of scan. Same values on the corresponding calibration and supplemental records. In fact satellite time code is computed at the beginning of each new scan line and inserted after the Line Sync Code (MinorFrame 0).
15	30	1	unsignedByte (B)	Tens of days, days.
15	31	1	unsignedByte (B)	Tens of hours, hours.
15	32	1	unsignedByte (B)	Tens of minutes, minutes.
15	33	1	unsignedByte (B)	Tens of seconds, seconds.
15	34	1	unsignedByte (B)	Tenths of seconds, hundreths of seconds.
15	35	1	unsignedByte (B)	Milliseconds, tenths of milliseconds.
15	36	1	unsignedByte (B)	Hundredths of milliseconds, thousandths of milliseconds.
Calibration values				
16	37	2	short (A)	Calibration lamp status
17	39	2	short (A)	Calibration lamps sequence number

18	41	830	string (A)	TM calibration values band 1. For ETM+ bands, length of this record is 986 bytes. Calibration values are results from the internal calibrator system which is a part of the instrument. They enable monitoring of the sensor's degradation and allow adjustement of calibration parameter. Calibration data provides bias data sequence (detector response within shutter phase) and a 50 pixel calibration "pulse" from the lamp (detector response to calibration lamp). These two sequences are mainly used for in-flight calibration method. ESA products are calibrated according to pre-flight method: for one band, pre-flight gain is used and offset is computed from the bias data sequence.
19	871	870 x6	string (B)	TM Calibration data record per band - contructed as group of fields 1:18 with fields number 1 up to 6 set to null value. For ETM+ bands, TM calibration data record length is 1026 bytes.

Part

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Chapter 6.1 Volume Directory File

6.1.1 Overview

The role of the Null Logical Volume is to end the set of volumes.

The last file following the last logical volume within a volume set is the Null Volume Directory File, consisting of one record only, its 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 another Volume Descriptor Record and appending the appropriate File Pointer Records.

6.1.2 Volume Descriptor Record

The table below details the structure of the Volume Descriptor Record. Fields 1 to 6 are binary encoded. All others fields are in ASCII. Alphanumeric character strings are by default left-justified and numeric character strings are right-justified. Any unused field is filled with ASCII blanks. Number which does not fill the field are padded with leading blanks.

The length of this record is 360 bytes.

Id	Byte	Len	Type, Encoding	Description
1	1	4	unsignedInt (B)	Record sequence number. It gives the sequence number of this record in the file. The value shall be between 1 and the number specified in field 29 of the Volume Descriptor Record.
2	5	1	unsignedByte (B)	1st record sub-type code.
3	6	1	unsignedByte (B)	Record type code for superstructure records.
4	7	1	unsignedByte (B)	2nd record sub-type code.
5	8	1	unsignedByte (B)	3rd record sub-type code for all superstructure records.
6	9	4	unsignedInt (B)	Length of this record (in bytes).
7	13	2	string (A)	ASCII / EBCDIC flag. It indicates if the alphanumeric information is encoded in ASCII or EBCDIC. (e.g. 'A$' for ASCII). Unless otherwise specified, $ represents a blank character.
8	15	2	string (A)	Blanks.
9	17	12	string (A)	Superstructure format control document identifier.
10	29	2	string (A)	Superstructure control document revision number. It indicates the revision number or letter of the Superstrucure Format Control Document. Coded $C, for the original draft.
11	31	2	string (A)	Superstucture record format revision letter. It indicates the revision letter of the Superstrucure records 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 Superstructure 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	33	12	string (A)	Superstructure software release number. It identifies the software revision used to write this logical volume.
Logical volume id				
13	45	3	string (A)	'MNS': Mission, Number and Sensor type (e.g. 'L7E' for Landsat 7 ETM). Part of the logical volume identifier.
13	48	2	short (A)	'YY': Year of acquisition
13	50	3	int (A)	'DDD': Day of acquisition

13	53	3	int (A)	'PPP': Path in WRS
13	56	3	int (A)	'RRR': Row in WRS
13	59	2	string (A)	'AA': Acquisition station identifier.
Physical volume id				
14	61	2	string (A)	'AA': Processing station identifier. Part of the physical volume identifier.
14	63	1	string (A)	'Q': Quadrant number.
14	64	2	short (A)	'YY': Year of product generation.
14	66	3	int (A)	'DDD': Day of product generation.
14	69	6	dateTime (A)	'HHMMSS': Hour, minute and second of product generation.
14	75	1	byte (A)	'N': The CCT or Exabyte sequence number.
14	76	1	byte (A)	'n': The number of CCTs or exabytes generated for current product.
Volume set id				
15	77	8	string (A)	Satellite name. Part of the volume set identifier.
15	85	1	string (A)	Satellite number.
15	86	7	string (A)	Instrument.
16	93	2	short (A)	Number of physical volumes in the set. It indicates the total number of Physical volume in a Volume Set. A blank field indicates that the information is was not avalaible at the time the Logical Volume was recorded.
17	95	2	short (A)	Physical volume number, start of logical volume. This field indicates the sequence number of the Physical volume within a volume set, which contains the 1st record of the Logical Volume.
18	97	2	short (A)	Physical volume number, end of logical volume. 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.
19	99	2	short (A)	Physical volume sequence number (i.e of current tape) - 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 for field 17. The value in this field must lie within 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).
20	101	4	int (A)	First referenced file number in this physical volume. 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 number count.
21	105	4	int (A)	Logical volume number within volume set. 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	109	4	int (A)	Logical volume number within physical volume. This is the sequence number of the present Logical Volume within a Physical Volume.
23	113	8	dateTime (A)	Logical volume creation date (Generation date reference field). It indicates the date when the Logical Volume was recorded. The format is "YYYYMMDD", where YYYY is the year, MM the month and DD the day.
24	121	8	dateTime (A)	Logical volume creation time (Generation time reference field). It indicates the time when the Logical Volume was recorded. The form of the code is "HHMMSSXX", where HH is the hour, MM the minute, SS the second and XX is hundredths of seconds.
25	129	12	string (A)	Logical volume generating country. It indicates the name of the country generating this logical volume.
26	141	8	string (A)	Logical volume generating agency. It indicates the laboratory or the center generating

				this logical volume.
27	149	12	string (A)	Logical volume generating facility. It indicates the computer facility on which the logical volume was recorded.
28	161	4	int (A)	Number of pointer records in this volume directory. This gives the number of data files in the logical volume.
29	165	4	int (A)	Total number of records this in volume directory. This is the number of File pointers records plus one (for this record), plus the number of Text Records.
30	169	4	int (A)	Number of logical volumes in the set.
31	173	88	string (B)	Spare segment. Reserved for future revisions of this record format.
32	261	100	string (B)	Local use segment. When unused this field is filled with blanks.

Part

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Chapter 7.1 Format overview

7.1.1 Physical media description

The CD-ROM is a random access type media of about 600 Megabytes of formatted data capacity.

The CD-ROM is seen by every system (MS-DOS, OS-2, UNIX etc ...) as organised in a hierarchical directory structure : the root directory and every sub directory below.

7.1.2 Logical volume description

The format is defined to preserve the original CEOS format of the tapes with a minimum of additions to comply with the direct access type structure of the CD-ROM.

The structure of the product is as follows:

- Root directory
- Sub-directory

Chapter 7.2 CD-ROM Content and format definition

7.2.1 Root directory

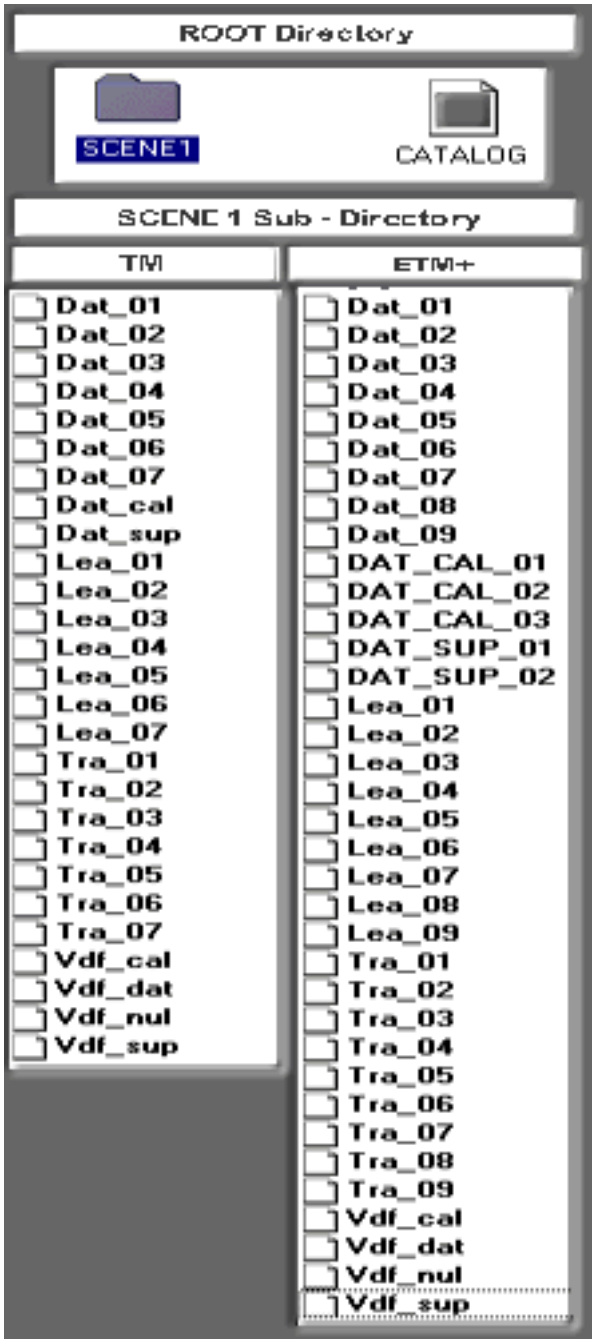
The root directory contains a CATALOG FILE which gives information about the product stored on CD-ROM.

7.2.2 Data set sub-directory

The data sub directory contains exclusivly all the files which could be on tape, as the volume directory file, leader file, imagery file ,etc ...This directory is called "SCENE1" and contains the following nine types of files:

- VDF_DAT.001 = Volume directory file of the imagery file.
- LEA_0n.001 = Leader file relative to band n of the imagery file.
- DAT_0n.001 = Data file relative to band n of the imagery file.
- TRA_0n.001 = Trailer file to band n of imagery file.
- VDF_DAT.001 = Volume directory file of the supplemental file.
- DAT_SUP.001 = Data file of the supplemental file.
- VDF_CAL.001 = Volume directory file of the calibration file.
- DAT_CAL.001 = Data file of the calibration volume.
- NUL_VDF.001 = Null volume.

7.2.3 CD ROM Layout



CD ROM layout

7.2.4 Catalogue file format definition

The format of the catalogue file is based on the IEF (Inventory Exchange Format) concept allowing the content of the medium to be compatible with the UIT (User Interface Terminal) tools and it is defined as follows (all fields are in ASCII):

Field	Bytes	Content
1	80	/* CEOS_IEF_FIXED_REFERENCE */
2	80	/* CPF */
3	80	/* YYMMDDHHMMSS */ As CD generation date and time
4	80	/* NEWACQ */
5	80	/* 00001 */
6	80	meta data line 1
7	80	meta data line 2

CD ROM Catalogue File

Field	Start bytes	Number of bytes	Description
1	1	3	Mission & Satellite identifier
2	4	3	Sensor/Instrument identifier
3	8	2	Resampling mode
4	12	3	Calibration mode
5	18	6	Product level
6	25	8	Acquisition date
7	33	6	Scene center time
8	39	6	Scene center time - same as field number 7
9	45	6	Acquisition station identifier
10	51	6	Archiving station identifier
11	58	3	Fixed reference row
12	62	3	Fixed reference frame - set to null value in case of floating scene
13	65	6	Image type
14	71	4	Quality parameters (not use)
15	75	7	band information in archived dataset
16	82	2	Processing identifier
17	84	2	Acquisition station code
18	86	4	Storage media indentifier
19	50	3	Processing level

Meta Data Line 1

Scene center coordinates embedded in the catalog file are not given for full scene but only for floating scenes.

Field	Start bytes	Number of bytes	Description
1	1	6	Latitude of scene center
2	7	6	Longitude of scene center
3	14	6	Latitude of scene center
4	20	6	Longitude of scene center
5	27	6	Latitude of scene center
6	33	6	Longitude of scene center
7	40	6	Latitude of scene center
8	46	6	Longitude of scene center
9	53	1	Ascending or descending flag
10	54	15	Quality parameters
11	80	1	Line number of this record

Meta Data Line 2

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