JMA HRIT

Mission Specific Implementation

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DOCUMENT CONTROL

Issue	Date	Status and Changes	
Issue 1	6 January 2000	Original Issue	
Issue 1.1	1 December 2000	1) Section 4.4.2.11 2) Section 4.4.2.12 3) Section 4.4.2.13 4) Appendix C	Header Type #130 – Explanations Header Type #131 – Explanations Header Type #132 – Explanations Link parameters Delete link budget example
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CHANGE TRACEABILITY from Issue 1.1 to Issue 1.2		
Location of change in issue 1.1	Change	Ref.
TABEL OF CONTENTS	- removing of 3.1.3 Meteorological Data - change of section numbering 3.1.4 to 3.1.3 - removing of 4.5.5 - change of appendix numbering	
Section 1.2	- modification of definition 'data rate'	
Section 1.3	- removing of appendix B - change of appendix numbering	
Section 1.4.1	- change of [AD.1] rev 2.4 to rev 2.6	
Section 1.6	- update of MSG LRIT/HRIT Mission Specific Issue 1.0 to Issue 4.1.9	
Section 2.2	- removing of Meteorological Data	
Section 3.1.1	- removing of 'Meteorological Data'	
Section 3.1.3	- removing all text	
Section 3.1.4	- change of Section numbering 3.1.4 to 3.1.3	
Section 4.2.1	- insertion of Number of image segment files might be changed in future due to the timeliness requirement	
Section 4.3	- removing Meteorological data - modification of mission specific file type - replacing of Table 4.1 LRIT File Types	
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APPENDIX A	- insertion of Number of image segment files might be changed in future due to the timeliness requirement - modification of A.1.2 - modification of A.1(removing of TBD and 'Sprit') - removing of A.1.4 - removing of A.1.5 - removing of A.2 - modification of A.3.1(removing of 'Sprit')	
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1. INTRODUCTION

1.1 Purpose of the Document

A Global Specification for Low Rate and High Rate Information Transmission (LRIT/HRIT) [AD.1] has been agreed by the Co-ordination Group for Meteorological Satellites (CGMS). The global specification is based on the ISO standard 7498 (OSI Reference Model) [RD.1] and the CCSDS recommendations of Advanced Orbiting Systems (AOS) [RD.2]. It defines the structure and the formatting of the LRIT/HRIT files and the processing and transport protocols of all OSI layers applicable to all geostationary meteorological spacecraft.

The purpose of the document, JMA HRIT Mission Specific Implementation, is the specification of the more detailed communication structure applied to the high rate transmission service of meteorological mission of the MTSAT (Multi-functional Transport SATellite).

This document defines the formatting manner from the view of the transmitting site; it further implies function from the receiving side (User Stations) point of view.

1.2 HRIT Service

The mission shall be named LRIT (Low Rate Information Transmission) if the communication link provides a data rate below 256k bit/s. If the rate is greater than or equal to 256k bit/s, the mission shall be named HRIT (High Rate Information Transmission).

The MTSAT dissemination service provides the HRIT service. The service is performed via one physical channel of the MTSAT with a data rate of 3.5Mega symbols per second.

1.3 Document Structure

A brief description of the contents of each of the sections is given below:

Section 2	provides an overview of the OSI layer reference model and its particular functionality.
Section 3	presents the data to be disseminated via JMA HRIT.
Section 4	introduces to the HRIT file structure in general and defines the mission specific file types and secondary headers.
Section 5	contains the required details about the compression and encryption algorithms.
Sections 6 to 8	summarize the mechanisms of formatting the data into source packets and transfer frames.
Section 9	defines the JMA HRIT mission specific parameters of the physical layer.
Appendix A	shows the file format of image data to be disseminated via the HRIT dissemination channel

Appendix B	defines the parameters of satellite to ground communication link
Appendix C	contains list of abbreviations used in this document
Appendix D	contains list of TBDs, TBCs

The handling of failure cases and the utilization of dissemination data are not covered by this document.

1.4. Applicable and Reference Documentation

1.4.1 Applicable Documentation

[AD.1] CGMS: 'LRIT/HRIT Global Specification', Rev 2.6,12 August1999

1.4.2 Reference Documentation

[RD.1] ISO: 'Information Processing System - Open System Interconnection - Basic Reference Model', ISO standard 7498-1, 1994
[RD.2] CCSDS: 'Advanced Orbiting Systems, Networks and Data links: Architectural Specification', CCSDS Recommendation 701.0-B2, November 1992
[RD.3] WMO: 'WMO Manual on the Global Telecommunications System', Publication number 386, 1992
[RD.4] CCSDS: 'Time code formats', CCSDS recommendation 301.0-B-2 April 1990
[RD.5] ISO: 'Information Technology - Digital Compression and Coding of Continuous-tone Still Image - Requirements and Guidelines, Compliance Testing and Extensions', ISO standards 10918-1, 10918-2, DIS 10918-3
[RD.6] Data Encryption Standard (DES), Federal Information Processing Standard (FIPS) PUB 46-2, U.S. Dept. of Commerce, National Institute of Standards and Technology, 30/12/93
[RD.7] DES Modes of Operation, FIPS PUB 81, U.S. Dept. of Commerce, National Institute of Standards, 2/12/1980
[RD.8] CCSDS: 'Telemetry channel coding', CCSDS recommendation 101.0-B-3, May 1992

1.5 Conventions

Data types and encoding rules given in this document follow the specifications of [AD.1]

1.6 Acknowledgment

This document is based on:
MSG LRIT/HRIT Mission Specific Implementation, EUMETSAT MSG/SPE/057, Issue 4.1.9 March 2001
This is prepared for JMA HRIT dissemination service.

JMA would like to express its sincere appreciation for the cooperation and assistance of EUMETSAT in preparing this document.

2. INTRODUCTION TO THE OSI REFERENCE MODEL

2.1 Communication Concept

This document conforms to [AD.1] which is based on the OSI Reference Model as defined in ISO 7498 [RD.1] and the CCSDS AOS, Network and Data Links, Architectural Specification [RD.2].

Table 2-1 presents the ISO/OSI layers from top to bottom and the equivalent functionality included in the HRIT communication model from the view of the transmission service.

OSI Layer	Layer Functionality
Application layer	- acquisition of application data
Presentation layer	- image segmentation - formatting to HRIT file structure
Session layer	- compression (if required) - encryption (if required)
Transport layer	- determination of APID - split of files into source packets
Network layer	- determination of VC-ID
Data link layer	- assembly of source packets into M_PDUs - multiplexing - assembly of VCDUs - generation of ‘idle frame’ - Reed-Solomon coding - randomization - attachment of sync marker
Physical layer	- serialization - viterbi coding - modulation

Table 2-1 HRIT ISO/OSI Layer Functionality

2.2 Dissemination

Start and end time of dissemination for an HRIT file is not bound to absolute time references. The dissemination service will maintain in principle a regular, periodic distribution of the image data. Service Messages will be interleaved with the image data according to a priority scheme.

3. APPLICATION LAYER

3.1 Input Data

3.1.1 General

The JMA HRIT service deals with the following application data:

- Image Data
- Service Messages

A brief description of the application data can be found in the sections 3.1.2 to 3.1.3.

3.1.2 Image Data

Image data corresponds to the geo-located and radiometrically pre-processed image data ready for further processing and analysis.
A list and description of these data is contained in Appendix A.

3.1.3 Service Messages

Service messages are data which are to provide the end-users with regular operational information (e.g. administrative and encryption key messages).

4. PRESENTATION LAYER

The presentation layer defines the uniform formatting of data and image segmentation. This layer receives the data as defined in section 3 from the application layer. The transfer mechanism of the MTSAT dissemination service is based on the transfer of data units which are called HRIT files. These files are the output of the presentation layer and their structure is explained in the following.

4.1 Structure of HRIT Files

Each application data unit will be formatted to an HRIT file or several HRIT files. An HRIT file consists of one or more header records and one data field.

The primary header record is mandatory and defines the file type and the size of the complete HRIT file. Depending on the file type, one or more secondary headers may be required to provide ancillary file information (see section 4.4).

primary header #0	secondary header record (#1-#127) as defined in sect. 4.4	secondary header record (#128-#255) as defined in sect. 4.4	data field

Figure 4-1 HRIT File Structure

4.2 Segmentation of HRIT Files

In order to allow for a management of the HRIT channel occupation and flexibility concerning the usage of compression schemes, the full Earth's disk image and half disk image data will be divided into a number of separate HRIT files. These files will be called *image segment files* from now on.

4.2.1 Segmentation of Image Data

- Full Disk Image

The full Earth's disk of MTSAT images will have a size of 11000 lines X 11000 pixels for visible channel, and a size of 2750 lines X 2750 pixels for infrared.

With an image segmentation size of 1100 lines (VIS) and 275 lines (IR), one complete Earth image will consist of 10 image segment files (1100 lines of 11000 columns for VIS, 275 lines of 2750 columns for IR).
The number of image segment files might be changed in future due to the timeliness requirement.
Figures 4-2 presents the above concept.

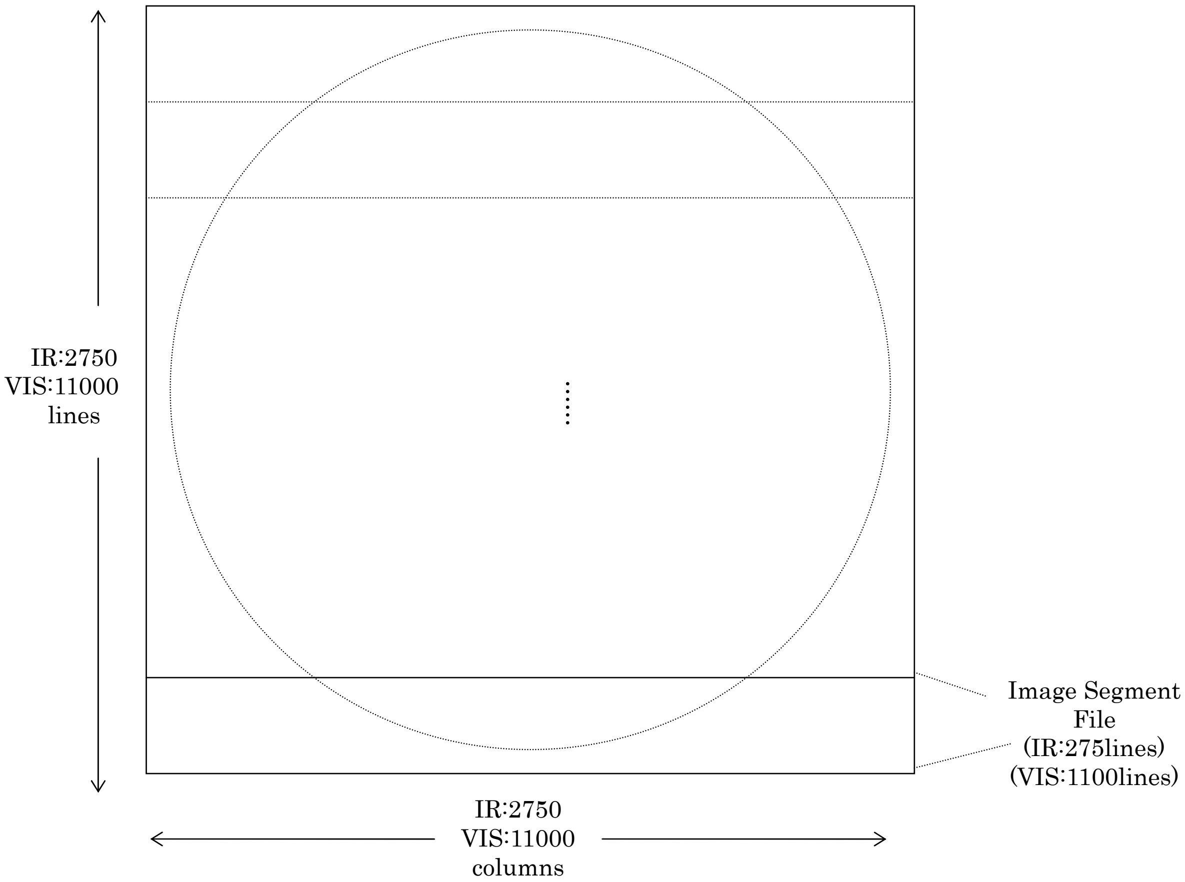

Figure 4-2 JMA HRIT image data file structure of full Earth's disk

The line direction will be from North to South and the column direction will be from West to East.

- Half Disk Image

There are two kinds of half earth's disk image. One is Northern Hemisphere, the other is Southern Hemisphere. The images will have a size of 5500 lines X 11000 pixels for visible channel, and 1375 lines X 2750 pixels for infrared channels.

With an image segmentation size of 1100 lines (VIS) and 275 lines (IR), one complete half Earth's disk image will consist of 5 image segment files (1100 lines of 11000 columns for VIS, 275 lines of 2750 columns for IR).
The number of image segment files might be changed in future due to the timeliness requirement.

- Small frame scan Image

The small frame scan images will have variable frame size.

4.3 Overview of HRIT File Types

The 'global' file types (0... 127) have already been defined in [AD.1]. In addition, the mission specific file types (128…255) are required for the JMA HRIT service to cover all data and information. The file types (128... 255) are available for future expansion.

Table 4-1 specifies all application data types identified and described in section 3 over the various HRIT file types.

File type code	File type	Application data type contained in the data field
Global HRIT file types		
0	image data	image data - full Earth's disk of normalized geostationary projection
1	GTS message	(not used in the JMA HRIT mission)
2	alpha-numeric text	regular operational messages - administrative messages
3	encryption key message	support of JMA HRIT encryption scheme
4 ... 127	reserved	(for further global use)
Mission specific HRIT file type		
128 ... 255	reserved	(for further mission specific use)

Table 4-1 HRIT File Types

4.4 HRIT File Header Types

4.4.1 General

The dissemination service will use the header types #0 - #7 of the LRIT/HRIT Global Specification as defined in [AD.1] and the mission specific headers #128 - #132 (see Table 4-2).

Code	Header record type	Structure
Headers as defined in LRIT/HRIT Global Specification		
0	primary header	according to [AD.1], LRIT/HRIT global specification
1	image structure	
2	image navigation	
3	image data function	
4	annotation	
5	time stamp	
6	ancillary text	
7	key header	
8... 127	reserved for further global usage	
Mission Specific Headers		
128	image segment definition	image segment file information
129	encryption key message header	encryption key message information
130	image compensation information header	image compensation information
131	image observation time header	image observation time
132	image quality information header	image quality information
133... 255	reserved	(for further mission specific use)

Table 4-2 Adaptation of HRIT Header Types

4.4.2 Definition of Header Types

4.4.2.1 Header Type #0 - Primary Header

The structure of the primary header record is:

Primary Header Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 0
Header_Record_Length	::=	unsigned integer (2bytes)	fixed value, set to 16
File_Type_Code	::=	unsigned integer (1byte)	defines file type
		0 : image data file 1 : GTS Message (not used) 2 : alphanumeric text file 3 : encryption key message	
Total_Header_Length	::=	unsigned integer (4bytes)	variable
			specifies total size of all header records.
Data_Field_Length	::=	unsigned integer (8bytes)	variable
			specifies total size of the HRIT file data field in bits, this parameter will be completed after compression of the data field.

Table 4-3 Primary Header

Explanations:

- File_Type_Code

  The File_Type_Code specifies the format of the data to be transmitted via HRIT files. The relationship between application data types and File_Type_Code is as defined in Table 4-1.

4.4.2.2 Header Type #1 - Image Structure

The structure of the image structure record is:

Image Structure Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 1
Header_Record_Length	::=	unsigned integer (2bytes)	fixed value, set to 9
NB		unsigned integer (1byte)	number of bits per pixel
NC		unsigned integer (2bytes)	number of columns
NL		unsigned integer (2bytes)	number of lines
Compression_Flag	::=	unsigned integer (1byte)	compression method
		0 : no compression 1 : lossless compression (default) 2 : lossy compression	

Table 4-4 Image Structure

Explanations:

- NB (number of bits per pixel)

  The value of NB will be: 16 for image data
  1 for overlay data.

- NC (number of columns)

  The value of NC will be:
  2750 : Full and half Earth's disk image data (IR)
  11000 : Full and half Earth's disk image data (VIS)
  Variable : Small frame scan image data.
  2752 : Overlay data for IR Earth's disk image data (see appendix A.2)

- NL (number of lines)

  The value of NL will be:
  275 : Full and Half Earth's disk image data due to the image segmentation (IR)
  1100 : Full and Half Earth's disk image data due to the image segmentation (VIS)
  Variable : Small frame scan image data.

- Compression_Flag

  The Compression_Flag defines the compression method.

4.4.2.3 Header Type #2 - Image Navigation

The structure of the image navigation record is:

Image Navigation Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 2
Header_Record_Length	::=	unsigned integer (2bytes)	fixed value, set to 51
Projection_Name	::=	character (32bytes) "GEOS(<sub_lon>)" ,	projection names as defined in [AD.1]
CFAC	::=	integer (4bytes)	column scaling factor as defined in [AD.1]
LFAC	::=	integer (4bytes)	line scaling factor as defined in [AD.1]
COFF	::=	integer (4bytes)	column offset as defined in [AD.1]
LOFF	::=	integer (4bytes)	line offset as defined in [AD.1]

Table 4-5 Image Navigation

Explanations:

- Projection Name

  The Projection Names will be:
  "GEOS(140.0)" for the full and half Earth's disk image.
  All unused characters will be set to ASCII 'space' (20h).

- CFAC / LFAC

  CFAC and LFAC are column and line scaling factors.

- COFF / LOFF

  COFF and LOFF are projection specific offsets about image data (as defined in section 3). Image data will be divided into a number of separate HRIT files, so you have to confirm the Image Segment Identification Header(section 4.4.2.9 Header Type #128) for define the position of an image segment file window within the projection area.

For a further description of the navigation functions the reader shall refer to [AD.1].

4.4.2.4 Header Type #3 - Image Data Function

This record determines the physical meaning of the image data, i.e. the relation between physical value and pixel count of the image data.
The structure of the image data function record is:

Image Data Function record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 3
Header_Record_Length	::=	unsigned integer (2bytes)	variable value
Data_Definition_Block	::=	character [ ]	variable size and contents in accordance with [AD.1 section 4.3.2]

Table 4-6 Image Data Function

Explanations

- Data_Definition_Block

  This character string allows defining data structures of images and overlays, or look-up table.

- Image Data

  The relation between count and physical value is defined.

  The image data physical value corresponding to minimum count (i.e. 0), maximum count (i.e. 65535), and designated count (i.e. 1023) are defined in principle. Linear interpolation is applied for bridging definition gaps of count to physical value.

  e.g. $HALFTONE := 16<CR> _NAME:=INFRARED <CR> _UNIT: =KELVIN<CR>
  0:=190.00<CR>1023:= 310.00<CR>65535:=310.00<CR>... etc.

- Overlay files:

  All overlay files are disseminated as single bit-plane. Zero represents the overlay to be off. One represents overlay condition

  e.g. $OVERLAY := 1<CR>

4.4.2.5 Header Type #4 - Annotation

The annotation record will be used to identify more precisely the product/data type included in the data field of the HRIT file. It is assembled to allow for quick and easy detection of the most relevant file contents.

It can be assumed that all operating system in use at the user station sites will support long file names. Therefore, it is proposed to use the annotation text as a default distinctive file name.

The structure of the annotation record is:

Annotation Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 4
Header_Record_Length	::=	unsigned integer (2bytes)	variable value, max. 67
Annotation_Text	::=	character [ ]	used as file name

Table 4-7 Annotation

Explanations

- Annotation_Text

  The Annotation_Text contains file name of data/products.

  List of file name of image data can be found in the Appendix A.

4.4.2.6 Header Type #5 - Time Stamp

The time stamp record will be written after the end of the session layer processing, i.e. after compression and encryption processing.
The structure of the time stamp record is:

Time Stamp Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 5
Header_Record_Length	::=	unsigned integer (2bytes)	fixed value, set to10
CDS_P_Field	::=	unsigned integer (1byte)	P-Field fixed value according to CCSDS bit 0 (MSB) = '0' bits 1-3 = '100' bits 4-7 = '0000'
CDS_T_Field	::=	unsigned integer (6bytes)	6 octets T-field according to CCSDS

Table 4-8 Time Stamp

Explanations

- CDS_T_Field

  As defined by the CDS_P_Field, the 6 octets CDS_T_Field consists of
  2 bytes counter of days starting from 1 January 1958
  4 bytes milliseconds of day

CCSDS time code format is specified in [RD.4].

4.4.2.7 Header Type #6 Ancillary Text

The structure of the ancillary text record is:

Ancillary Text Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 6
Header_Record_Length	::=	unsigned integer (2bytes)	variable value, max. 65532
Ancillary_Text	::=	character [ ]	text

Table 4-9 Ancillary Text

Explanations

- Ancillary_Text

  The Ancillary_Text will contain descriptive text.

4.4.2.8 Header Type #7 - Key Header

The structure of the key header record is:

Key Header Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 7
Header_Record_Length	::=	unsigned integer (2bytes)	fixed value, set to 7
Key_Number	::=	unsigned integer (4bytes)	index of the used MGK

Table 4-10 Key Header

Explanations

- Key_Number

The 4 bytes Key_Number consists of
2 bytes key group identifier
1 byte corresponding to the file type code as defined in section 4.3
1 byte key identifier

The keys are divided into two groups as follows:

key group identifier = '0000'h : Key group 1
key group identifier = '0001'h : Key group 2

The reason for identifying two key groups is that the JMA HRIT encryption scheme will make use of a system whereby the actively used key group will be swapped from one to the other in regular intervals.

4.4.2.9 Header Type #128 - Image Segment Identification

The structure of the image segment identification record is:

Image Segment Identification Record		
Header_Type	::= unsigned integer (1byte)	fixed value, set to 128
Header_Record_Length	::= unsigned integer (2bytes)	fixed value, set to 7
Image_Segm_Seq_No	::= unsigned integer (1byte)	image segment sequence number
Total_No_Image_Segm	::= unsigned integer (1byte)	total number of image segments
Line_No_Image_Segm	::= unsigned integer (2bytes)	line number of the image segment

Table 4-11 Image Segment Identification

Explanations

- Image_Segm_Seq_No

  Image segmentation is applied to the following data to be disseminated as file type #0

  Full Earth's disk image
  Half Earth's disk image

  No image segmentation is applied to the following data:

  Overlays (coastlines, etc.)

  If no segmentation is applied, Image_Segm_Seq_No will be set to 0.

- Total_No_Image_Segm

  Total number of image segment will be set to 10 for the full Earth's disk image data and 5 for the half Earth's disk image data.
  If no segmentation is applied, Total_No_Image_Segm will be set 1.

- Line_No_Image_Segm

  The line number relative to COFF/LOFF (Header Type #2) of the first line for the each image segment will be set.

4.4.2.10 Header Type #129 - Encryption Key Message Header

The structure of the encryption key message record is:

Encryption Key Message Header Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 129
Header_Record_Length	::=	unsigned integer (2bytes)	fixed value, set to 5
Station_Number	::=	unsigned integer (2bytes)	index of the user station

Table 4-12 Encryption Key Message Header

Explanations

- Station_Number

  The Station_Number is used to identify an authorized user station.

4.4.2.11 Header Type #130 – Image Compensation Information Header

The structure of the image compensation information record is:

Image Compensation Information Header Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 130
Header_Record_Length	::=	unsigned integer (2bytes)	variable value, max 65532
Image Compensation Information	::=	character [ ]	text

Table 4-13 Image Compensation Information Header

Explanations

- Image Compensation Information:

  Actual column and line offset (COFF and LOFF) coefficients will be provided for compensation to COFF and LOFF in Image Navigation header (Header Type #2) of nominal values.
  Values of COFF and LOFF of both the first and the last line in each segment will be set, and more those of other lines may be subsidiarily set if necessary. Values of COFF and LOFF for all other lines within each segment can be calculated by linear interpolation from the given values.
  Function of the COFF and LOFF in this header is same as those in Image Navigation header (Header Type #2) except for representation of numeric value. Each value is described in ASCII character form for a real number represented to the first decimal place.

  Example)
  LINE := 1<CR>COFF:=1375.2<CR>LOFF:=1374.9<CR>
  LINE := 101<CR>COFF:=1375.3<CR>LOFF:=1374.8<CR>
  LINE := 201<CR>COFF:=1375.4<CR>LOFF:=1374.6<CR>
  LINE := 275<CR>COFF:=1375.4<CR>LOFF:=1374.5<CR>

  In this case, values of COFF and LOFF for the first line are 1375.2, 1374.9, those for the last line are 1375.4, 1374.5 and additional values are stored every 100 lines.

4.4.2.12 Header Type #131 – Image Observation Time Header

The structure of the image observation time record is:

Image Observation Time Header Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 131
Header_Record_Length	::=	unsigned integer (2bytes)	variable value, max 65532
Image Observation Time	::=	character [ ]	text

Table 4-14 Image Observation Time Header

Explanations

- Image Observation Time

Image observation time of both the first line and the last line in each image segment will be set and that of other lines will be additionally set if necessary. Image observation time for all other lines within each segment can be calculated by linear interpolation from the given values.
Value is expressed with Modified Julian Day (MJD) and is described in ASCII character form for a real number represented to the sixth decimal place.

Example)
LINE := 1<CR>TIME:=52535.123456<CR>
LINE := 101<CR>TIME:=52545.123456<CR>
LINE := 201<CR>TIME:=52555.123456<CR>
LINE := 275<CR>TIME:=52562.123456<CR>

In this case, Image observation time of the first line is 55235.123456 of MJD, that of the last line is 52562.123456 and additional values are stored every 100 line

4.4.2.13 Header Type #132 – Image Quality Information Header

The structure of the image quality information record is:

Image Quality Information Header Record			
Header_Type	::=	unsigned integer (1byte)	fixed value, set to 132
Header_Record_Length	::=	unsigned integer (2bytes)	variable value, max 65532
Image Quality information	::=	character [ ]	text

Table 4-15 Image Quality Information Header

Explanations

- Image Quality Information

Image Quality Information is set to error rate of each line, if there was the error on transmission and observation in the lines. The error rate is calculated with the percentage by using the information of transmission error on the satellite line and bit synchronization error in the receiving units.
It describes as "NO_ERROR" in the case that there is not the error with all the lines.

Example)
LINE:=10<CR>ERROR:=0.0005<CR>

In this case, value of error rate is expressed with 0.05 % on the line number 10.

4.4.3 File Type vs. Header Implementation

The global mandatory/optional use is specified in [AD.1]. Table 4-16 defines the JMA HRIT mission specific use of header record types within certain HRIT file types. 'JMA mandatory use' means that the identified header record will always be used in the JMA HRIT dissemination. 'JMA optional use' means that only certain HRIT files contain such header record.

file types	header record types												
	0	1	2	3	4	5	6	7	128	129	130	131	132
0: image data file	●	●	◎	◎	◎	◎		○	◎		◎	◎	◎
1: GTS message													
2: alpha-numeric text file	●					◎		○					
3: encryption key message	●					◎				◎			

Remarks:

● as requested by [AD.1]
◎ JMA mandatory use
○ JMA optional use

0	primary header
1	image structure
2	image navigation
3	image data function
4	annotation
5	time stamp
6	ancillary text
7	key header
128	image segment identification
129	encryption key message header
130	image compensation information header
131	image observation time header
132	image quality information header

Table 4-16 Use of Header Records vs. File Type

4.5 Detailed File Type Description

4.5.1 File Type #0 - Image Data

File type #0 will be used for image data and overlay data (latitude/longitude lines and shorelines).

The file type #0 may contain compressed and/or encrypted data. Such data will be flagged in the relevant secondary headers. Further detailed information about the algorithm of compression can be found in section 5.

The JMA HRIT service applies no encryption to the file type #0.

A detailed data format can be found in the Appendix A.

4.5.1.1 Image Data

This type of data corresponds to the geo-located and radiometrically pre-processed image data. The corresponding projection and coverage information is defined by the image navigation header. The physical meaning of the image data is defined by the image data function header.

4.5.1.2 Overlay Data

The overlay data including latitude/longitude lines and shorelines will consist of single bit plane. The overlay information is handled in the same manner as image data. The corresponding projection and coverage information is defined by the image navigation header.

4.5.2 File Type #1 - GTS message

The file type 'GTS Message' will contain data coded in conformance to [RD.3].

The JMA HRIT service does not use the file type #1

4.5.3 File Type #2 - Alpha-numeric Text

This file type will mainly be used for the regular distribution of text-oriented service messages (e.g. administrative messages, etc.).

Each message will have to contain a unique sequence number which allows the user to discard messages which have already been received previously.

4.5.3.1 MANAM Text

The MANAM Text will contain a schedule of observation and distribution. It will be inform per a day or whenever the schedule is changed.

4.5.3.2 Cancellation Report

This type of data will contain cancellation of observation, and be informing whenever it is necessary.

4.5.3.3 Observation Report

The Observation Report will contain a result of observation and be disseminated user.

4.5.4 File Type #3 - Encryption Key Message

The Encryption Key Message will contain a complete set of encrypted message keys of all key number.

A detailed data format can be found in section 5.4.5.

5. SESSION LAYER

5.1 General

The session layer provides the means for interchange of data. In the JMA HRIT, this layer includes the definition of data compression and encryption.

5.2 Input to Session Layer

The HRIT files as shown in Figure 4-1 are the input to the Session Layer processing.

5.3 Compression

5.3.1 General

Compression is required to maximize the data available in the HRIT channel.

The ISO standard 10918 'Digital compression and coding of continuous-tone still images' [RD.5] known as JPEG is chosen as the compression baseline for the JMA HRIT service. It supports lossy and lossless schemes.

The selection of the compression type and compression factor for the JMA HRIT service will be based on a schedule and will allow for adjustment of the HRIT channel occupation. The selected compression type and compression factor will be kept stable on single HRIT file.

Compressed HRIT files will be self-describing, i.e. the JPEG interchange format includes all required tables and other relevant information for the decoding process. The quantization and coding tables will be kept stable on single HRIT file.

Data compression will operate on single HRIT file. The compression flag (CFLG) of the image structure record (header type #1) is set to 1 or 2.

Compression will only be applied to file type #0 (image data).
No compression to HRIT file types other than file type #0 (image data) is applied.

Compression will operate on the HRIT file data field only and will leave all header data unmodified. After compression, the HRIT file will contain a compressed data field as depicted in Figure 5-1.

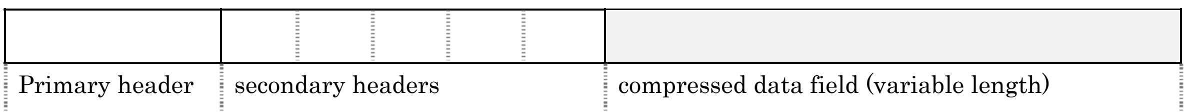

Figure 5-1 HRIT File Structure with compressed data field

5.3.2 Introduction to Lossy JPEG Compression

The JPEG lossy compression scheme supports 8-bit or 12-bit pixel resolution. Input to the lossy JPEG coders are data arrays sized 8x8 pixels. In a first step, a discrete cosine transform (DCT) turns each data array of intensity data into an array of frequency data. Each of the frequency data values from the DCT is quantized in conjunction with a quantization table. The two-dimensional quantized DCT coefficients are then converted to a serial bit stream according to a zig-zag sequence and the results are entropy coded (compressed).

The following lossy DCT-based modes of compression exist:

- baseline process (only 8-bit, only Huffman coding, only sequential scan)
- extended process (8-bit or 12-bit, Huffman or arithmetic coding, sequential and progressive scans)
- hierarchical process

Figure 5-2 shows the principle of lossy compression. For further information on the lossy compression algorithm, refer to [RD.5].

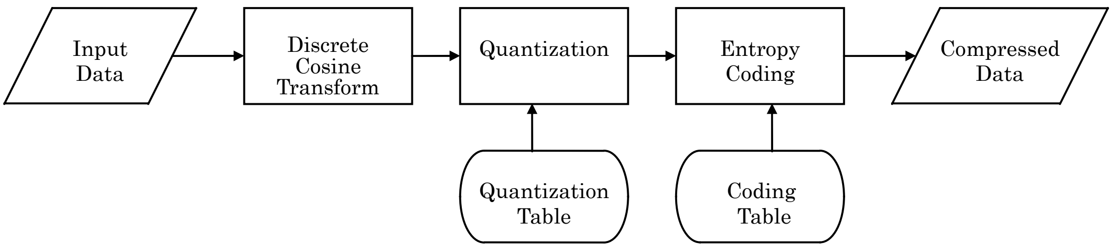

Figure 5-2 Lossy JPEG Compression Scheme

5.3.3 Introduction to Lossless JPEG Compression

This section provides a short introduction to the JPEG lossless compression.

The lossless JPEG scheme is based on a prediction of the pixel value. The lossless JPEG coders support input precision of 2... 16 bits per sample. A set of predictors is defined. The pixel value is coded as a difference of the pixel value to that prediction. No blocking structure of the image data and no DCT-based encoding are used in the lossless compression mode.

Two lossless modes of compression are possible:

- lossless process with Huffman coding
- lossless process with arithmetic coding

Figure 5-3 shows the principle of lossless compression. For further information on the lossless compression algorithm, refer to [RD.5].

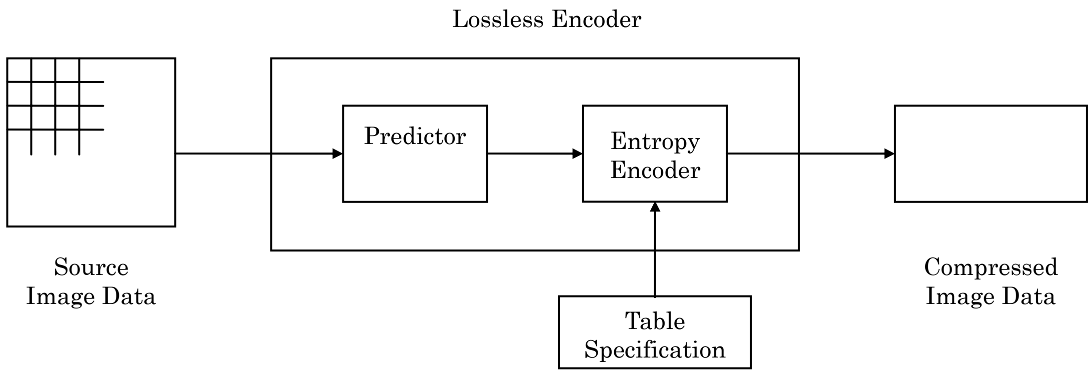

Figure 5-3 JPEG Lossless Image Compression Scheme

5.3.4 HRIT Mission specific JPEG Implementation

This section defines the mission specific JPEG implementation. This includes the definition of the overall structure, the used compression processes, the coding applied and the detailed marker segments.

5.3.4.1 Mission specific JPEG Structure and supported Modes

The JPEG compression encoding process will transform the data field of an HRIT image file into one JPEG image in accordance with the data format definitions given in [RD.5]. Figure 5-4 shows the JPEG compressed image data structure closely following these definitions and the used terminology. The figure already includes certain assumptions about the JPEG modes used for the JMA HRIT concept.
The JMA HRIT will only make use of the following JPEG modes:

- sequential mode (as opposed to progressive - no multi-scans)
- non-interleaved mode (single spectrum, no multi-components)
- non-hierarchical mode (non-differential coding - no multi-frames)

Consequently, one JPEG image contains one frame with only one scan embedded between start of image (SOI) and end of image (EOI) markers. A JPEG scan will contain an entropy coded segment (ECS) of one component.

An ECS contains minimum coded units (MCU). In the case of DCT-based (lossy) processes an MCU originates from an 8x8 pixel array. For lossless processes, an ECS consists of at least a pixel row.

Huffman entropy coding will form the baseline for the JMA HRIT service.
No arithmetic coding will be used for the JMA HRIT service.

The output of the JPEG process creates a byte aligned output as described in [RD.5]

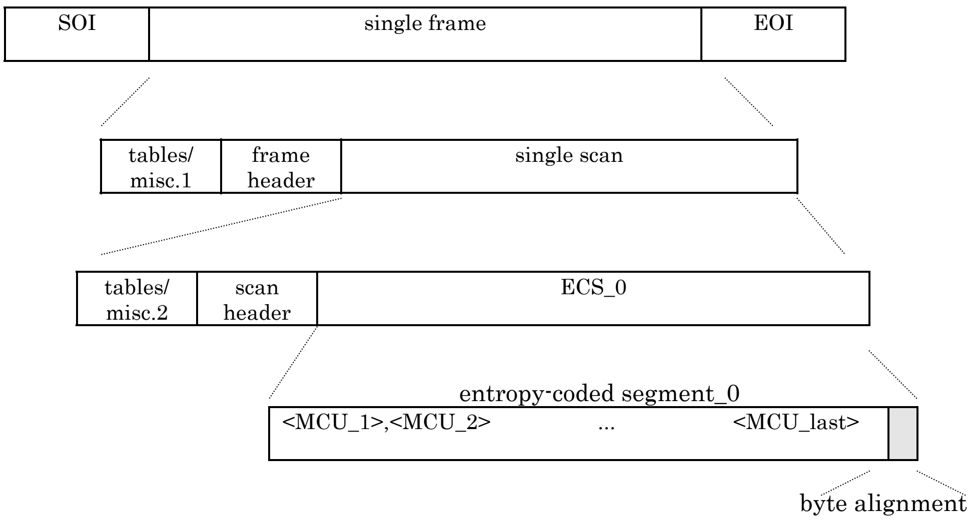

Figure 5-4 JPEG structure of compressed image data

SOI Start of Image Marker
EOI End of Image Marker
ECS Entropy coded segment
MCU Minimum coded unit

5.3.4.2 JPEG Frame Header Structure

The JPEG frame header directly follows the 'tables/misc.1' field. It specifies the applied JPEG encoding process via its 'Start of Frame' marker (SOF) and provides information about size and component structure. Figure 5-5 and Table 5-1 provide all details of the JMA HRIT mission specific JPEG implementation.

The following restrictions apply:
- only a sub-set of all possible SOF will be used
- only parameters of a signal component will be contained

The structure of a JPEG Frame Header is:

SOF	Lf	P	Y	X	Nf	C_1	H_1	V_1	Tq_1
						single component parameters			

Figure 5-5 SOF structure

Frame Header			
SOFn	::=	unsigned integer (2bytes)	start of frame marker
		'FFC0'h : baseline DCT	SOF_0 (Huffman coding)
		'FFC1'h : extended sequential DCT	SOF_1 (Huffman coding)
		'FFC3'h : spatial sequential lossless	SOF_3 (Huffman coding)
Lf	::=	unsigned integer (2bytes)	frame header length, fixed value, set to 11
P	::=	unsigned integer (1byte)	sample precision
Y	::=	unsigned integer (2bytes)	number of lines
X	::=	unsigned integer (2bytes)	number of samples per line
Nf	::=	unsigned integer (1byte)	number of image components, fixed value, set to 1 (only single component is supported)
C_1	::=	unsigned integer (1byte)	component identifier
H_1	::=	binary (4bits)	horizontal sampling factor, fixed value, set to 1
V_1	::=	binary (4bits)	vertical sampling factor, fixed value, set to 1
Tq_1	::=	unsigned integer (1byte)	quantization table selector, fixed value, set to 0

Table 5-1 Frame Header Structure

5.3.4.3 JPEG Scan Header Structure

The JPEG scan header directly follows the 'tables/misc.2' field. It specifies further component specific parameters, selects entropy coding tables and their start values. Figure 5-6 and Table 5-2 provide all details of the JMA HRIT mission specific JPEG implementation.

The following restrictions apply:
- only a SOF sub-set will be used
- only parameters of a single component will be contained

The scan header will have the following structure:

SOS	Ls	Ns	Cs_1	Td_1	Ta_1	Ss	Se	Ah	Al
			single component parameters						

Figure 5-6 SOS structure

Scan Header			
SOS	::=	unsigned integer (2bytes)	start of scan marker, set to 'FFDA'h
Ls	::=	unsigned integer (2bytes)	frame header length, fixed value, set to 8
Ns	::=	unsigned integer (1byte)	number of image components, fixed value, set to 1
Cs_1	::=	unsigned integer (1byte)	scan component selector, fixed value, set to 0
Td_1	::=	binary (4bits)	DC entropy coding table selector, fixed to 0
Ta_1	::=	binary (4bits)	AC entropy coding table selector, fixed to 0 table 0 for lossy compression, N/A (0) for lossless compression
Ss	::=	unsigned integer (1byte)	start of spectral or predictor selection 0 for lossy processes, 1-7 according to predictor table (see [RD.5 annex H])
Se	::=	unsigned integer (1byte)	end of spectral selection 63 for lossy processes, 0 for lossless processes
Ah	::=	binary (4bits)	successive approximation bit position high, fixed value, set to 0
Al	::=	binary (4bits)	successive approximation bit position low or point transform 0 for lossy processes, 0 .. 15 for lossless processes

Table 5-2 Scan Header Structure

5.3.4.4 Structure of Table and Miscellaneous Marker Segments

The JMA HRIT mission specific JPEG implementation will use the following tables and miscellaneous marker segments:

- define quantization table(s) (DQT)
- define Huffman table(s) (DHT)

- Define Quantization Table Marker (for lossy JPEG compression only)

In the case of DCT-based encoding processes (lossy compression), the 'Define Quantization Table' Marker will be contained in the 'tables/misc.1' field(s) preceding the 'Start of Frame' Marker. Its syntax will follow the specification given in [RD.5].

Only one quantization table will be contained in one JPEG image.

The structure of the quantization table marker (DQT) is:

DQT	Lq	Pq	Tq	Q_0	Q_1	.....	Q_{63}
		single table only					

Figure 5-7 Quantization table structure

Quantization table structure			
DQT	::=	unsigned integer (2bytes)	fixed value, set to 'FFDB'h
Lq	::=	unsigned integer (2bytes)	quantization table length, set to 67 or 131
Pq	::=	binary (4bits) 0 : baseline DCT 1 : extended DCT	quantization table element precision
Tq	::=	binary (4bits) 0 : table 0 1 : table 1 2 : table 2 3 : table 3	quantization table identifier Only one table will be used at a time the default value will be 0
Qk	::=	unsigned integer[64] (1byte/2bytes) unsigned integer (1byte), if Pq=0 unsigned integer (2bytes), if Pq=1	quantization table elements value range for baseline DCT (1 .. 255) value range for extended DCT (1 .. 65535)

Table 5-3 DQT Marker

Define Huffman Table Marker

The 'Define Huffman Table' Marker syntax will follow the specification given in [RD.5]. This marker will be contained in the 'Tables/Misc.2' field directly following the 'SOF' marker. Not more than two 'DHT' markers (one DC table 0 and one AC table 0) will be contained per JPEG image.

The structure of one 'Define Huffman Table' marker (DHT) is:

DHT	Lh	Tc	Th	L_1	L_2	.....	L_{16}	HUFFVAL_list

Figure 5-8 Huffman table structure

Huffman table structure			
DHT	::=	unsigned integer (2bytes)	fixed value, set to 'FFC4'h
Lh	::=	unsigned integer (2bytes)	Huffman table definition length, variable value
Tc	::=	binary (4bits) 0 : DC table 1 : AC table	table class
Th	::=	binary (4bits) 0 : table 0 1 : table 1 2 : table 2 3 : table 3	Huffman table identifier Only one table will be used at a time the default value will be 0
Li	::=	unsigned integer[16] (1byte)	number of Huffman codes of length i
HUFFVAL_list		unsigned integer[MT] (1byte)	list of values associated with each Huffman code of length i according to the Huffman coding model

Table 5-4 DHT Marker

Definition of MT:

$$MT = \sum_{i=1}^{16} Li(t)$$

5.4 Encryption

The JMA HRIT service includes a mechanism to control the access to HRIT.

5.4.1 Encryption Principle

The encryption algorithm will only operate on the data fields of HRIT files and leave all header records unmodified. The encryption principle is based on the substitution and transposition for the clear data.

If encryption is applied to the HRIT data field, a key header (header type #7) as defined in section 4.4.2.8 will be part of the header records preceding the data field. The keys will be distributed separately via the file type #3 (encryption key message, see section 4.5.4).

The encryption and decryption are based on a processing in accordance with the Electronic Code Book (ECB) mode of Data Encryption Standard (DES). This mode avoids error propagation in an error prone communication system. The DES process is described in [RD.6]. The ECB is defined in [RD.7].

Figure 5-9 shows the principle of encryption and decryption.

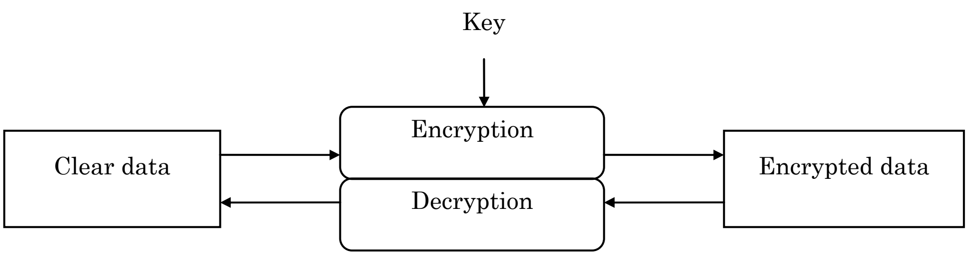

Figure 5-9 Encryption Principle

5.4.2 Key Definition

The HRIT encryption infrastructure requires two types of keys:

- User Station Keys (USK)
- Message Keys (MGK)

- User Station Keys - USK

User Station Keys are secret elements which are fixed.

User Station Keys are used:

- at the Key Center for Message Key encryption with the relevant User Station Key
- at the user station for the Message Key recovery

The Key Center generates for each user stations a specific USK. Each USK is dedicated to a user station.

- Message Keys - MGK

Message Keys are secret elements generated by the Key Center and which are to be considered static. MGK sets are updated periodically. MGKs are transmitted to the user stations via dissemination in encrypted form. MGKs are used to encrypt/decrypt the HRIT data field.

5.4.3 Key Representation

The DES key consists of 64 bits, 56 of which are used as a decode/encode key (forming the active key) and 8 of which are parity bits to detect errors in the key.

The DES key numbering convention shown in Figure 5-10 conforms to [RD.6]. The 64 bits per a DES key are numbered from left to right. Bits (8, 16, 24,..., 64) are used for the parity checking of each 8-bit byte. The parity of the octet is odd.

DES Key	56 bit key + 8 bit parity K(1), K(2), K(3),... , K(64)

notation of K(n) : n = DES Key bit number

In the case, keys are distributed via communication means, K (1) equals by definition to the MSB (CCSDS Bit 0) and is transmitted first.

Figure 5-10 DES Key decomposition

All DES keys used in the HRIT encryption scheme, namely the USKs and the MGKs will follow this convention and contain real parity bits.

5.4.4 Key Function

The Key Center generates a specific User Station Key (USK) and a specific Station Number for each authorized user station. They are provided to the authorized users (NMSs/NHMSs) in written document. The function of USK is to avoid any unauthorized use of Message Keys (MGKs).

Message Keys (MGKs) are generated by the Key Center and used to encrypt/decrypt the HRIT files.

An HRIT file is encrypted with an MGK selected by the Key Center. The Encrypted HRIT file is accompanied by a Key Header (header type #7). The Key Header contains Key Number of MGK used in encryption process.

The encrypted HRIT file is decrypted with the MGK specified by the Key Number.

The Key Center assembles an Encryption Key Message (file type #3) which consists of some sets of Key Number and MGK. Each Encryption Key Message is generated for each authorized user station, is encrypted with each USK, and is periodically disseminated to the user stations.

The Encryption Key Message is accompanied by an Encryption Key Message Header (header type #129) which contains Station Number. MGKs can be retrieved from the Encryption Key Message with only the USK identified by the Station Number.

MGKs stored in the each user station are replaced with the latest MGKs retrieved from the Encryption Key Message.

MGKs are divided into two key groups: Key groups 1 and 2. In each HRIT file its Key Header designates which key group is used for encryption/decryption. A key group used for encryption/decryption is called the active key group and that not used is called the inactive key group. When MGKs are updated, the inactive key group is updated. The inactive key group is activated at a certain time.

The function diagram is shown in Figure 5-11.

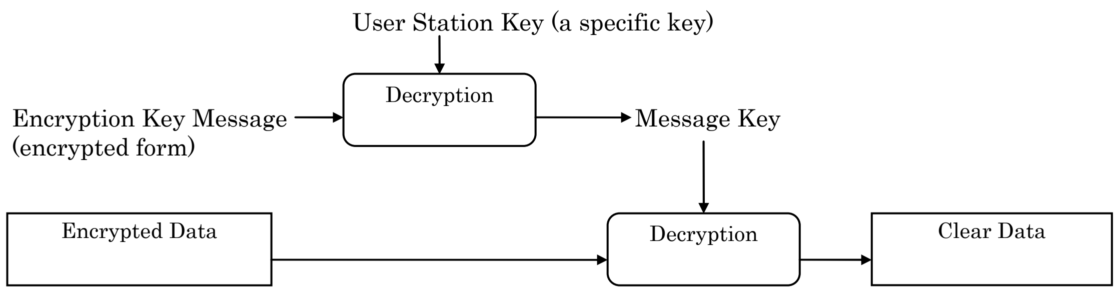

Figure 5-11 Function Diagram

The following procedures are applied at the user station:

(Pre-setting)

1) Input the USK and Station Number for the user station from the keyboard.

(Processing of Encryption Key Message)

2) The Encryption Key Message for the user station is selected using its Station Number.
3) The Encryption Key Message is decrypted using its USK and is stored in the data processing unit.

(Processing of HRIT data file)

4) The applicable MGK is determined from the Encryption Key Message in the data processing unit using the Key Number in the Key Header of the HRIT data file.
5) The HRIT data file is decrypted with the applicable MGK.

(Procedures from 2) to 5) are carried out automatically.)

5.4.5 Encryption Key Message File

The Encryption Key Message will contain a complete set of message keys of all key number for an authorized user station.

The Encryption Key Message file will be encrypted entirely with the relevant USK and generated for every authorized user station.

The structure of the Encryption Key Message file is:

set #1		set #2			set #n	
key No.	MGK	Key No.	MGK	....	Key No.	MGK
4 bytes	8 bytes	4 bytes	8 bytes		4 bytes	8 bytes

Figure 5-12 Encryption Key Message File

5.5 Session Layer Output

Output of the session layer to the transport layer is the session protocol data unit (S_PDU) containing the variable length compressed and encrypted data field as shown in Figure 5-13.

If neither compression nor encryption has been applied, the session layer will leave the data field unmodified.

In any case the session layer processing will have to determine the data field length and fill it into the primary header and to add the time stamp (if required) before it passes the complete data unit as S_PDU to the transport layer.

The transport layer is called by the session layer with the following syntax:

TRANSPORT.request (S_PDU, PRIO)

Primary header	secondary headers					compressed and encrypted data field

Figure 5-13 HRIT Session Protocol Data Unit (S_PDU)

6. TRANSPORT LAYER

6.1 General

The transport layer receives the S_PDUs as a transport service data unit (TP_SDU) which is a variable length file as shown in Figure 5-13 and the parameters PRIO.

The determination of the application process identifier (APID) will be performed according to [AD.1].

The transport files are split into one or more blocks of 8190 bytes size which form the user data field of the source packet. The last block may be shorter and contain 1... 8190 bytes. Each user data field will be followed by a 2-octet Cyclic Redundancy Check (CRC).

6.2 Source Packetization

6.2.1 Source Packet Structure

This section defines in detail the source packet structure:

Source Packet Header (48 bits)							Packet Data Field (variable)	
Packet Identification				Packet Sequence Control			User Data Field	
Version No 3 bits	Type 1 bit	Secondary Header Flag 1 bit	APID 11 bits	Sequence Flags 2 bits	Packet Sequence Count 14 bits	Packet length 16 bits	Application Data Field variable	Packet Error Control (CRC) 16 bits
2 octets				2 octets		2 octets	max.8190 octets	2 octets

Figure 6-1 Source Packet Structure (TP_PDU)

Version No — The version No. bits will be set to 000, identifying the Version-1 CCSDS packet.

Type — Set to 0. Type is not used in CCSDS AOS.

Secondary header flag — Set to 1 if the user data begins with a header field, set to 0 else.

APID — see Table 6-1

Application Process Identifier (APID)	Application
0 ... 2015	HRIT application data
2016 - 2046	reserved by CCSDS (not used for HRIT)
2047	Fill Packets

Table 6-1 Application Process Identifiers

Sequence Flag — as defined in [AD.1]

Packet Sequence Count — 14-bit Packet Sequence Count, straight sequential count (modulo 16384) which number each source packet generated per APID.

Packet Length — 16-bit binary count which expresses the length of the remainder of the source packet following this field minus 1.

Application Data Field — contains up to 8190 octets of user data, i.e. a block of the TP_SDU

Packet Error Control — The 16 bit CRC forms the trailer of the user data field. It has to be derived as defined in [AD.1].

The CRC is computed over the entire application data field. The generator polynomial is

$$g(x) = x^{16} + x^{12} + x^{5} + 1$$

The encoder shall be initialized to 'all ones' for each application data field.

6.3 Transport Layer Output

The transport layer output is the protocol data unit TP_PDU which is identical to the source packet as depicted in Figure 6-1. This will be forwarded as service data unit to the Network Layer via

Packet.request (CP_SDU, APID)

7. NETWORK LAYER

7.1 Input to Network Layer

The source packets as shown in Figure 6-1 are the CCSDS path service data units (CP_SDU) forming the input to the Network Layer.

7.2 General

The Network Layer represents the CCSDS AOS path layer. The only function in the HRIT service is the generation of a Virtual Channel Identifier (VC-ID). The data received from the transport layer is transparently routed to the Data Link Layer.

7.3 Network Layer Processing

The VC-ID is generated as a value resulting from an integer division of APID by 32. APID will be set to 0 ... 2015. APID beyond 2015 must not be used with HRIT. Thus VC will be set to 0 ... 62. The used VC-IDs depend on APID assigned to the application data.

7.4 Output of Network Layer

The Network Layer output is the

M_UNITDATA.request (CP_PDU, VCDU-ID).

The CCSDS path protocol data unit (CP_PDU) is identical to the initial CP_SDU just forwarded through the network layer.

8. DATA LINK LAYER

8.1 Input to Data Link Layer

The Network Layer provides the CP_PDUs as multiplexing service data units (M_SDU) to the data link layer.

8.2 General

The Data Link Layer is implemented by the CCSDS AOS space link layer. It consists of two sub-layers:

- virtual channel link control (VCLC) sub-layer
- virtual channel access (VCA) sub-layer

As described in section 8.3 the VCLC sub-layer processing provides the multiplexing service only. This includes filling of M_SDUs into multiplexing protocol data units (M_PDU). Fill packets may have to be generated for the completion of the M_PDUs after time-out expiration.

The VCA sub-layer generates the virtual channel data units (VCDU), performs Reed-Solomon coding, data randomization and attachment of synchronization markers, and will generate 'fill-VCDUs' as specified in section 8.4.2 to maintain continuous data delivery to the physical layer.

8.3 VCLC Sub-layer Processing

The VCLC sub-layer processing performs the multiplexing and the M_PDU generation in accordance with [AD.1].

The M_PDUs will consist of 886 octets of which 2 octets are the M_PDU header and the 884 octets are the M_PDU packet zone as shown in Figure 8-1.

M_PDU header		M_PDU packet zone				
spare 5 bit	first header pointer 11 bit	end of M_SDU #(k-1)	M_SDU #k	M_SDU #(k+1)	...	beginning of M_SDU #m
2 octets		884 octets				

Figure 8-1 M_PDU Structure

The M_PDUs are passed to the VCA sub-layer service as VCA_UNITDATA.request (M_PDU, VCDU-ID).

8.3.1 Fill Packet Generation

In case that a partly generated M_PDU cannot be completed since no more M_SDU is available for the related virtual channel, a fill packet is generated to complete the M_PDU. The structure of this fill packet is shown as follows:

Version	‘000’
Type	‘0’
Secondary Header Flag	‘1’
APID	2047
Sequence Flag	’11’ (unsegmented)
Packet length	as required
User Data Field	’all zeros’

8.4 VCA Sub-layer Processing

8.4.1 VCDU Assembly

The M_PDUs from the VCLC layer are received as VCA_SDUs from the VCLC sub-layer and are used to assemble virtual channel data units (VCDU) according to [AD.1].
'VCDU' generation the following constant 'packetized data rate' for the HRIT dissemination channels will be achieved.
HRIT 3.5Mbps(Max Through put data rate≒2.9Mbps+FEC and Fraction adjustment)

note: The 'packetized data rate' is defined as the data stream after formatting and packetization, and before FEC cording and transmission. More precisely, it is the data at the VCDU level excluding sync marker and R-S check symbols.

The VCDU structure is shown in Figure 8-2.

VCDU primary header	VCDU data unit zone
6 octets	886 octets

Figure 8-2 VCDU structure

The decomposition of the VCDU header is given in Figure 8-3.

Version number	VCDU-ID		VCDU counter	signalling field	
	S/C ID	VC ID		replay flag	spare
2 bit	8 bit	6 bit	24 bit	1 bit	7 bit

Figure 8-3 VCDU Primary Header
Mission specific use:

Version Number '01'
VCDU-ID The S/C IDs represent the disseminating spacecraft.

MTSAT-1R : 11010101(D5,HEX)
MTSAT-2 : 11111000(F8,HEX)

The VC ID is as specified in section 7.3.
VCDU Counter as defined in [AD.1]
Signalling Field 'all zeros'

note: The 'VCDU Counter' will restart from 'zero or Overlap' after configuration changes in the Dissemination Element.

8.4.2 'Fill VCDU' Generation

The VCA sub-layer processing will automatically generate a 'fill-VCDU' in the case no or not sufficient VCDUs (underflow condition) to maintain a continuous data flow to the physical layer.
The definition of a 'fill-VCDU' is:

Version	'01'	
VCDU-ID	S/C ID	depending on used S/C (see list in section 8.4.1)
	VC ID	'63'h ('all ones')
VCDU Counter	as defined in [AD.1]	
Signalling Field	'all zeros'	
VCDU Data Unit Zone	fill pattern 'all zeros'	

note: The 'Fill VCDU Counter' will restart from 'zero or Overlap' after configuration changes in the Dissemination Element.

8.4.3 Reed-Solomon Coding

The HRIT dissemination service is a Grade-2 service, therefore, the transmission of user data will be error controlled using Reed-Solomon coding as an outer code.

The used Reed-Solomon code is (223,255) with an interleaving of I=4 according to [RD.8]

The VCDUs will be attached by 128 octets of Reed-Solomon check symbols to form a coded VCDU (CVCDU).

VCDU Primary header	VCDU data unit zone	Reed-Solomon Check Symbols
6 octets	886 octets	128 octets

Figure 8-4 CVCDU Structure

8.4.4 Randomization

Randomization is applied to all HRIT CVCDUs. It is a process which a pseudo-random sequence is bitwise exclusive-ORed to all 8160 bits of the CVCDU to ensure sufficient data transitions.

The pseudo-random sequence shall be generated using the following polynomial:

$$h(x) = x^8 + x^7 + x^5 + x^3 + 1$$

This sequence begins at the first bit of the CVCDU and repeats after 255 bits, continuing repeatedly until the end of the CVCDU. The sequence generator is then re-initialized to all-ones for the processing of the next CVCDU.

The first 40 bits of the pseudo-random sequence from the generator are shown below; the left-most bit is the first bit of the sequence to be exclusive-ORed with the first bit of the CVCDU; the second bit of the sequence is exclusive-ORed with the second bit of the CVCDU, and so on.

1111 1111 0100 1000 0000 1110 1100 0000 1001 1010 ...

8.4.5 Sync Marker Attachment

An attached synchronization marker (ASM) will have to precede the randomized CVCDU to allow for frame synchronization. The 32 bit pattern can be represented in hexadecimal notation as:

1ACFFC1D

The ASM and together with the CVCDU create the channel access data unit (CADU) of 1024 octets length.

8.4.6 Serialization and Output of the Data Link Layer

As a final task the VCA sub-layer performs the serialization of the CADU and provides the serial bit-stream to the physical layer.

9. PHYSICAL LAYER

The physical layer on the HRIT service performs the convolutional coding of the serialized data stream and its modulation onto the RF up-link signal.

The used convolutional coding in principle conforms to [RD.8] with the exception that no symbol inversion will be performed in the G2 path.

The complete parameter sets of the physical layer are specified in the Appendix C.

The RF carrier maintains a continuous modulation not to exceed the specified power flux density.

APPEDIX A – FILE FORMAT OF IMAGE DATA

A.1 Image Data

HRIT will provide image data produced from data observed with the MTSAT. The image data correspond to geo-located and radiometrically pre-processed image data. The image data files consist of one image of a particular spectral channel.

Five types of image data will be disseminated as below:

1. Full Earth's disk image of normalized geostationary projection.
2. Half Earth's disk (North or South) image normalized geostationary projection.
3. Small frame scan image of normalized geostationary projection.
4. Image of Polar-stereographic Projection.
5. Image of Mercator Projection.

- Normalized geostationary projection

The line direction will be from North to South and the column direction will be from West to East. The numbering of the image segment files will follow the line direction.
The number of bits per pixel is 16.
Lossless compression is applied to the image data.
Spatial resolution of the image is around 4 km(IR),1 km(VIS) at the sub-satellite point.
The projection parameters and the definition of count to physical value relation are described in the secondary header record of HRIT. For a description of the navigation function, refer to [AD.1, section 4.4].

Visible image
Infrared 1(10.5μ–11.5μ)
Infrared 2(11.5μ–12.5μ)
Infrared 3(6.5μ–7.0μ)
Infrared 4(3.5μ–4.0μ)
Infrared 5(spare)

Table A-1 Channel of image data for MTSAT-1R

A.1.1 Full Earth's Disk Image of Normalized Geostationary Projection

The full Earth's disk image data file is divided into 10 separate files. These files are called image segment files. The complete full Earth's disk image has a size of 11000 line X 11000 pixels for visible image and 2750 line X 2750 pixels for infrared images. With an image segmentation size of 1100 lines (VIS) and 275 lines (IR), one complete image will consist of 10 image segment files (1100 lines of 11000 columns for VIS, 275 lines of 2750 columns for IR).
The number of image segment files might be changed in future due to the timeliness requirement.

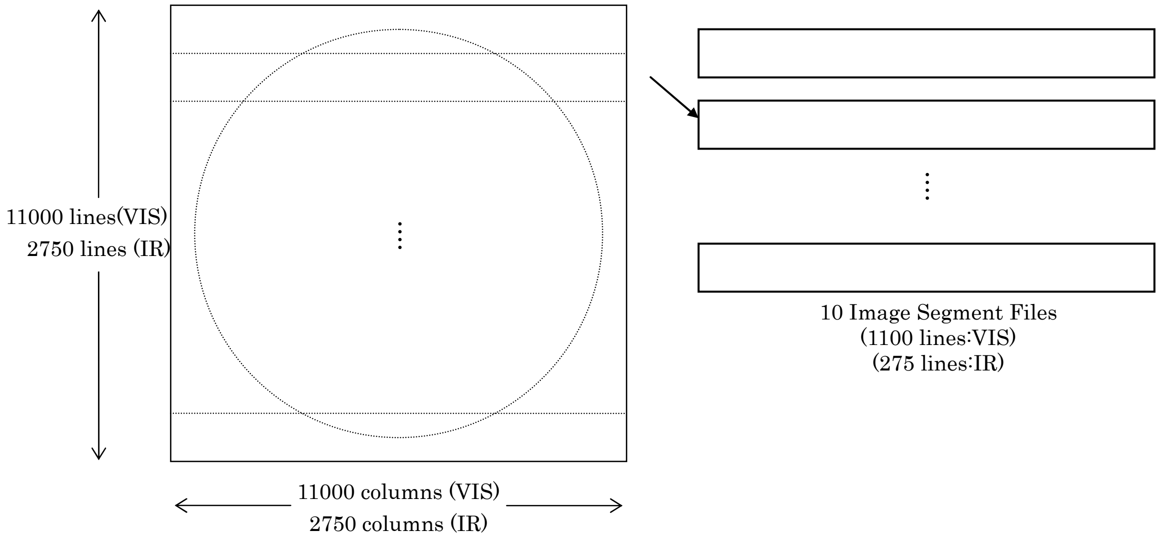

Figure A-1 Segmentation of full Earth's disk

Figure A-2 shows latitude/longitude lines and shorelines for full earth's disk image.

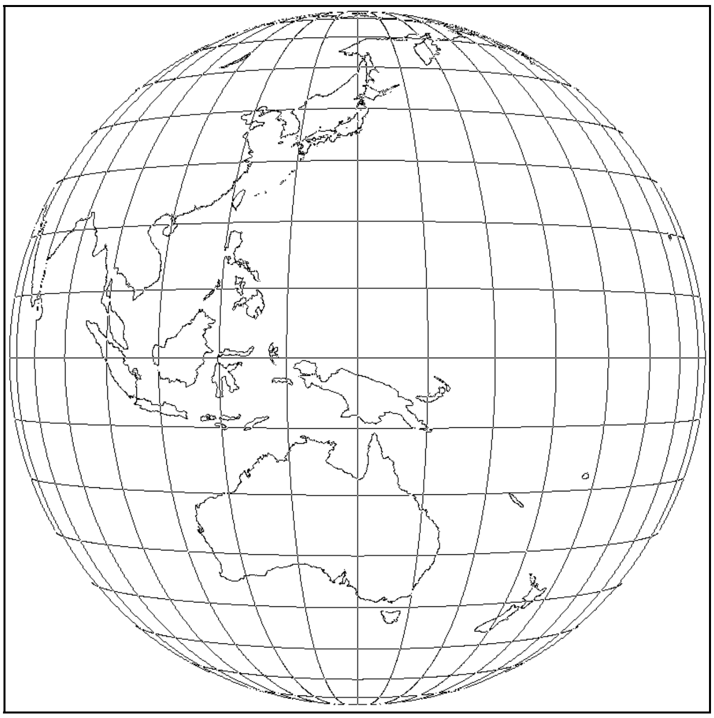

Figure A-2 Full Earth's Disk of Normalized Geostationary Projection

A.1.2 Half Earth's Disk Image of Normalized Geostationary

There are two kinds of half part of the full earth image. One is Northern Hemisphere, the other is southern hemisphere.

The half part of the image data file is divided into 5 separate files. These files are called image segment files. The complete half Earth's disk images have a size of 5500 lines X 11000 pixels for visible channel and 1375 lines X 2750 pixels for infrared channels. With an image segmentation size of 1100 lines (VIS) and 275 lines (IR), one complete image will consist of 5 image segment files (1100 lines of 11000 columns for VIS, 275 lines of 2750 columns for IR).
The number of image segment files might be changed in future due to the timeliness requirement.
Figure A-3 shows latitude/longitude lines and shorelines for Northern half earth's disk image.

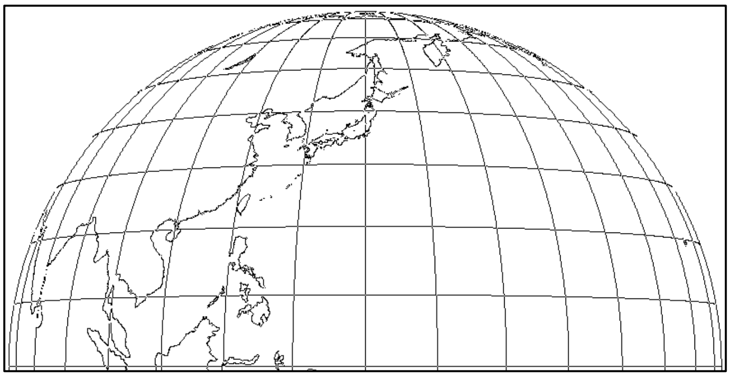

Figure A-3 Half Earth's Disk of Normalized Geostationary Projection

A.1.3 Small Frame Scan Image of Normalized Geostationary

The small frame scan image has variable line and pixel size. Figure A-4 shows latitude/longitude lines and shorelines.

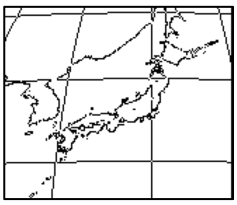

Figure A-4 Small Frame Scan Image of Normalized Geostationary Projection

A.2 Overlay

The overlay including latitude/longitude lines and shorelines consists of single bit plane compressed in lossless form. The overlay information is handled in the same manner as image data. The number of bits per pixel is 1. Zero represents the overlay to be off. One represents overlay condition. The corresponding projection and coverage information is defined in the secondary header record of HRIT.
Note that the JPEG lossless compression does not support compression of 1 bit per pixel image. Overlay data is treated as 8 bit per pixel data in compression process. Each pixel is formed by taking 8 consecutive pixels of overlay data (first pixel is MSB, last pixel is LSB). The number of lines is not changed.
Thus, the number of columns of overlay data file for infrared images of full and half Earth's disk(equal to 2752) is larger than that of corresponding image data file(equal to 2750) .

The following overlay files will be disseminated periodically.

- Full Earth's disk image of normalized geostationary projection

  The overlay for full Earth's disk image has a size of 11000 lines X 11000 pixels for visible image and 2750 lines X 2752 pixels for infrared images. No segmentation is applied to the overlay file.

  Refer to Figure A-2 for latitude/longitude lines and shorelines.

- Half Earth's disk image of normalized geostationary projection

  The overlay for full Earth's disk image has a size of 5500 lines X 11000 pixels for visible image, and 1375 lines X 2752 pixels for infrared image. No segmentation is applied to the overlay file.

  Refer to Figure A-3 for latitude/longitude lines and shorelines.

- Small frame scan image of normalized geostationary projection

  The overlay for full Earth's disk image has variable line and pixel size.

  Overlay of Small frame scan image is created and distributed each observation.

A.3 File Name

The file name of character strings is stored in the Annotation Header (Header Type #4). The name of image data files disseminated via HRIT is defined as follows:

File Type	Product name
Ffff	as defined in the following section
4 bytes	max. 60 bytes

Table A-2 File name of image data

A.3.1 File Name of Image Data

The record of file name for Image Data is used as follows:

- File Type

  ffff : 'IMG_' for image data

- Product name

projection name	spectral channel	observation time	sequence number
pppp	cccc	YYYYMMDDhhmm	nnnn
4 bytes	4 bytes	12 bytes	4 bytes

pppp : 'DK01' for full Earth's disk of normalized geostationary projection
'DK02' for North Earth's disk of normalized geostationary projection
'DK03' for South Earth's disk of normalized geostationary projection
'SF01' for Small frame image of normalized geostationary projection

cccc : 'VIS_' for visible channel
'IR1_' for infrared channel 1 (11μm)
'IR2_' for infrared channel 2 (12 μm)
'IR3_' for infrared channel 3 (6.7μm)
IR4_' for infrared channel 4 (3.7μm)

YYYYMMDDhhmm : YYYY=year, MM=month, DD=day of month, hh=hour, mm=minute

nnnn : '_001'-'_010' for segmented full earth's disk image data files
Sequence number is set only for dissemination of the segment files.

e.g. IMG_DK01IR1_200012312332_001

segment image data file #1 of full Earth's disk of normalized geostationary projection for infrared channel 1 observed at 2332 UTC on December 31, 2000.

A.3.2 File Name of Overlay Data

The record of file name for Overlay Data is used as follows:

- File Type

ffff : 'OVL_' for overlay data

- Product name

projection name	channel type
pppp	4 bytes

pppp : 'DK01' for full Earth's disk of normalized geostationary projection
'DK02' for North Earth's disk of normalized geostationary projection
'DK03' for South Earth's disk of normalized geostationary projection

TBD : File name of Small Frame Scan Image's Overlay Data

channel type: '_VIS' for Visible channel
'_IR_' for Infrared channel (IR1-IR5,SP1-SP3)

e.g. OVL_DK01_VIS
overlay data file of full Earth's disk of normalized geostationary projection for visible channel.

APPENDIX B - JMA HRIT SATELLITE TO GROUND INTERFACE

B.1 Communication Link Parameters

Parameters of communication link are specified as follows.

Table B.1 Parameters of JMA HRIT communication link

Parameters	
Center Frequency	1687.1MHz
EIRP	25.0 dBw
Polarization	Linear (Perpendicularity to orbital plane)
Band width (99% of total power)	5.2 MHz
Pulse shaping	Root Raised cosine, roll-off factor $\alpha = 0.5$
Total coded data rate	3.5 Msps
Modulation	PCM/NRZ-M/QPSK
Coding	concatenated coding Reed-Solomon(255,223)＋convolutional coding (1/2 rate, k=7)
Packetized data rate (on CVCDU level)	3.5 Mbps
Length of coded CVCDU	1020 octets

APPENDIX C - LIST OF ABBREVIATIONS

AOS	Advanced Orbiting Systems
APID	Application Process Identifier
ASM	Attached Synchronization Marker
BER	Bit Error Rate
CADU	Channel Access Data Unit
CVCDU	Coded VCDU
CCSDS	Consultative Committee for Space Data Systems
CGMS	Co-ordination Group for Meteorological Satellite
DCT	Discrete Cosine Transformation
DEC	Decryption Process
DES	Data Encryption Standard
DHT	Define Huffman Table (JPEG marker)
DQT	Define Quantization Table (JPEG marker)
Eb/No	Bit Energy/Noise Density
ECB	Electronic Code Book (DES mode)
ENC	Encryption Process
FEC	Forward Error Correction
GMS	Geostationary Meteorological Satellite
GRIB	WMO standard for the coding of binary information
GTS	Global Telecommunication System
HRIT	High Rate Information Transmission
ISO	International Organization for Standardization
JPEG	Joint Photographic Expert Group
LRIT	Low Rate Information Transmission
LSB	Least Significant Bit
MSB	Most Significant Bit
OSI	Open Systems Interconnection
RF	Radio Frequency
S/C	Spacecraft
SDUS	Small-scale Data Utilization Station
SKU	Station Key unit
SOF	Start of Frame (JPEG marker)
SOS	Start of Scan (JPEG marker)
TBC	To Be Confirmed
TBD	To Be Defined
UBM	User Station Base band Module
USK	User Station Key
VCA	Virtual Channel Access
VCLC	Virtual Channel Link Control
VCDU	Virtual Channel Data Unit
WMO	World Meteorological Organization

APPENDIX D - LIST OF TBDS AND TBCS

- TBDs

  A.3.2 File Name of Overlay Data
  File name of Small Frame Scan Image's Overlay Data

- TBCs