Issue 1.2 November 30, 2010

Communication, Ocean and Meteorological Satellite

COMS HRIT Mission Specific Implementation

Keywords
< COMS, MDUS, HRIT >

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Foreword

This specification has been produced by the Korea Meteorological Administration (KMA).

Should KMA modify the contents of the present document, it will be re-released by KMA with an identifying change of release date and an increase in version number as follows:

Issue x.y

where:

- x the first digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- y the second digit is incremented when editorial only changes have been incorporated in the document.

1 INTRODUCTION

1.1 Purpose

Global Specification for High Rate Information Transmission (HRIT) is written in Co-ordination Group of Meteorological Satellites (CGMS), based on the CCSDS recommendations of Advanced Orbiting System (AOS) and the ISO standard 7498 (describing the OSI reference model). These documents define the structure and the formatting of the HRIT files and the processing and the transport protocols of all OSI layers applicable to all geostationary meteorological spacecraft.

The purpose of this document, COMS HRIT Mission Specific Implementation, is to specify more detailed communication structure applied to the meteorological data dissemination service of the Communication, Ocean, and Meteorological Satellite (COMS).

It defines the formatting from the view of the transmitting site. It further implies functionality from the receiving side (User Stations) point of view, which is in principle a reverse mechanism of the formatting defined in this document.

1.2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies

Applicable documents:

[AD 1]	CGMS: 'LRIT/HRIT Global Specification' Rev 2.6.August 1999
[AD 2]	KARI: 'COMS Data Acquisition and Transmission Subsystem Specification' C1-SP-811-001 Rev. B, Dec. 27 2006
[AD 3]	Notification of CCSDS ID for COMS, C1-FX-0607-0294
[AD 4]	COMS GS-IPT-004 Rev. 2.0
[AD 5]	KARI: 'COMS HRIT Mission Specification' C1-SP-810-004C Rev. I, Jan. 2010

Reference documents:

[RD 1]	ISO: 'Information Processing System - Open System Interconnection - Basic Reference Model' ISO standard 7498, Feb. 1982
[RD 2]	CCSDS: 'Networks and Data Links: Architectural Specification' CCSDS Recommendation 701.0-B-3-S, June 2001
[RD 3]	CCSDS: 'Time code formats' CCSDS recommendation 301.0-B-3 January 2002
[RD 4]	CCSDS: 'TM Synchronization and Channel Coding' CCSDS recommendation 131.0-B-1, September 2003
[RD 5]	KMA: 'COMS-1: Requirements for Proposal in Meteorological Observation Mission' KMA/COMS/URD/001-ver1.0, 2004
[RD 6]	KARI, C1-FX-0809-0776, Sep. 2008.
[RD 7]	WMO CBS: 'A Guide to the Code Form FM 92-IX Ext. GRIB Edition 1'
[RD 8]	WMO: 'WMO Manual on the Global Telecommunications System' Publication number 386, 1992

[RD 9] ISO: 'Information Technology - Digital Compression and Coding of Continuous-tone Still Image - Requirements and Guidelines, Compliance Testing and Extensions' ISO standards 10918-1, 10918, DIS 10913-3

[RD 10] 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 11] DES Modes of Operation FIPS PUB 81, U.S. Dept. of Commerce, National Institute of Standards, 2/12/1980

[RD 12] JMA: 'JMA HRIT Mission Specific Implementation' Issue 1.2, 1 January, 2003

1.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

APID	Application Process Identifier
APNH	Asia and Pacific in Northern Hemisphere
CADU	Channel Access Data Unit
CVCDU	Coded Virtual Channel Data Unit
CCSDS	Consultative Committee for Space Data Systems
CGMS	Co-ordination Group for Meteorological Satellite
COMS	Communication, Ocean and Meteorological Satellite
CP_PDU	CCSDS Path Protocol Data Unit
DES	Data Encryption Standard
ECB	Electronic Code Book (DES mode)
ENH	Extended Northern Hemisphere
FD	Full Disk
GRIB	Gridded Binary
GTS	Global Telecommunication System
HRIT	High Rate Information Transmission
ISO	International Organization for Standardization
JPEG	Joint Photographic Expert Group
KMA	Korea Meteorological Administration
LSB	Least Significant Bit
LSH	Limited Southern Hemisphere
MAC	Media Access Control
MSB	Most Significant Bit
NWP	Numerical Weather Prediction
M_PDU	Multiplexing Protocol Data Unit
OSI	Open Systems Interconnection
RF	Radio Frequency
S/C	Spacecraft
SDUS	Small-scale Data Utilization Station
TBC	To Be Confirmed
TBD	To Be Defined
TP_PDU	Transport Protocol Data Unit
VCDU	Virtual Channel Data Unit
WMO	World Meteorological Organization

2 OSI REFERENCE MODEL

2.1 Communication Concept

The COMS HRIT dissemination service is based on the Open Systems Interconnection (OSI) Reference Model in [RD1] and the CCSDS AOS in [RD2].

Table 1 presents the functionalities of the each OSI layer from the view of dissemination system.

Table 1 OSI Layer Functionalities for the COMS HRIT Service

OSI 7 layers	Layer functionalities
Application layer	Acquisition of application data
Presentation layer	Image segmentation, HRIT file structuring
Session layer	Compression (if required) Encryption (if required)
Transport layer	Determination of APID Split of files into source packet
Network layer	Determination of VCID
Data link layer	Multiplexing, Error of block unit detection, Reed-Solomon encoding Randomization Attachment of sync marker
Physical layer	Serialization, Viterbi encoding, Modulation

Figure 1 shows hierarchical data structures of each layer of the LHGS/MDUS systems through the COMS HRIT dissemination services. Remained sections in this document will describe details of each layer in top-down direction in the corresponding chapter.

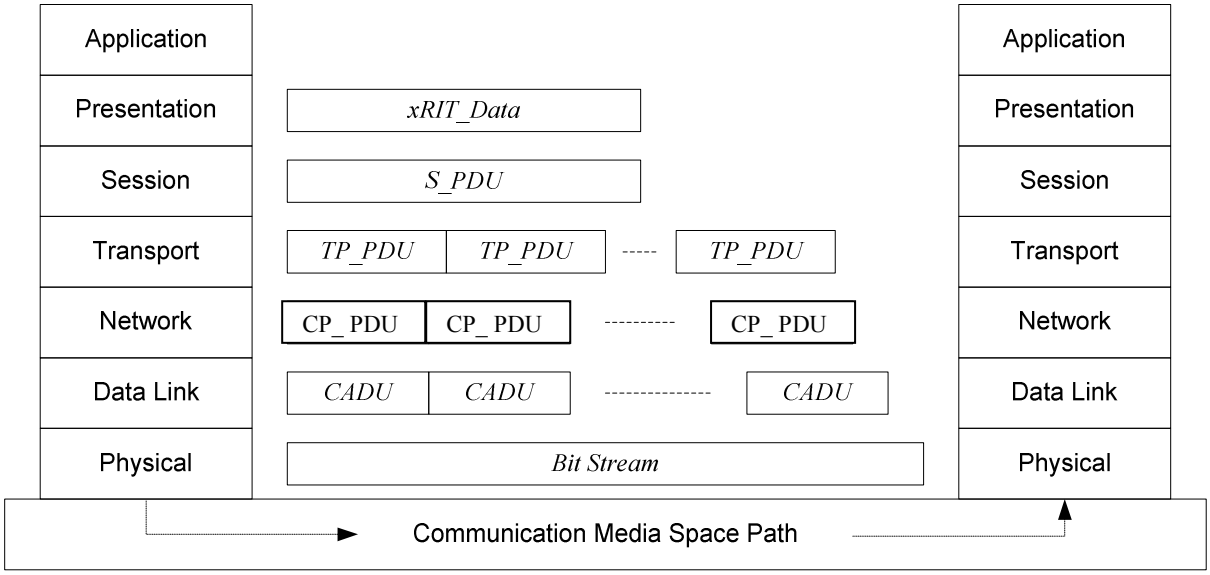


Figure 1 Definition of COMS HRIT Data Type

3 APPLICATION LAYER

3.1 Data Type

COMS HRIT service will provide specific application data from external system in the Application Layer as follows,

Image Data : FD, ENH, LSH, APNH

Additional Data : Alphanumeric text files

3.1.1 Image Data

The type of image data consists of visible channel image and infrared channel image. The projection type of COMS HRIT is GEOS. The images defining latitude, longitude, and size are distributed. The size of infrared channel image is a quarter of visible channel image in COMS HRIT. The size of visible channel image is 11000×11000, and the size of infrared channel image is 2750×2750. The data of the image is known by 4.4.3 Header Type #2 Image Navigation. The image size is represented by width×height. The image data in HRIT files is stored in little-endian byte orders and 10-bit full resolution of MI image in all channels and observation mode.

3.1.1.1 FD Image

FD (Full Disk) image is the normalized image of COMS satellite at the geosynchronous orbit 128.2 degrees. The size of visible channel image is 11000×11000 and the size of the infrared channel image is 2750×2750. Figure 2 is the observation area of FD image.

Figure 2 The observation mode of FD Image

3.1.1.2 Regional Area Image

Regional area image consists of APNH, ENH, and LSH.

3.1.1.1.1 APNH (Asia and Pacific in Northern Hemisphere) Image

APNH image is the image of Asia and Pacific in Northern Hemisphere. The size of visible channel image is 4056×3060 and the size of infrared channel image is 1014×765. Figure 3 is the observation area of APNH image.

Figure 3 The observation area of APNH Image

3.1.1.2.2 ENH (Extended Northern Hemisphere) Image

ENH image is the image of extended Northern Hemisphere. The size of visible channel is 7736×6176 and the size of infrared channel image is 1934×1544. Figure 4 is the observation area of ENH image.

Figure 4 The observation area of ENH(Bold), LSH(Dotted Line) Image

3.1.1.2.3 LSH (Limited Southern Hemisphere) Image

LSH image is the image of Limited Southern Hemisphere. The size of visible channel is 7736×3184 and the size of infrared channel image is 1934×796. Figure 4 is the observation area of LSH image.

3.1.2 Additional Data

Additional data of COMS HRIT consists of alphanumeric text transferred by defining file type code 2 [AD 1].

More detailed specification is described in chapter 4, presentation layer. Data type of COMS HRIT is described in Table 2.

Table 2 Data Type of COMS HRIT

Data type	Data
Image data	FD, APNH, ENH, LSH
Ancillary data	Alphanumeric text

4 PRESENTATION LAYER

The presentation layer shall handle image segmentation and HRIT file formatting. Both main functionalities and COMS HRIT file/header types will be explained in this chapter.

4.1 Segmentation of COMS HRIT Image Files

Image segmentation is performed for COMS HRIT dissemination services in real-time and for high flexibility with the HRIT compression/encryption schemes. Compression and encryption is processed with the unit of segment. The whole HRIT images are composed of a number of HRIT files (image segment files).

Figure 5 shows the image segment structure of COMS HRIT FD. The column direction will be from West to East and the line direction will be from North to South.

The FD image data is divided into 10 separate files. One segment size of HRIT FD image data for VIS channel is 11000 columns×1100 lines because the size of HRIT FD image data for VIS channel is 11000 columns×11000 lines and the size of each segment is identical. Table 3 presents image segment information of each observation mode. APNH image is not segmented.

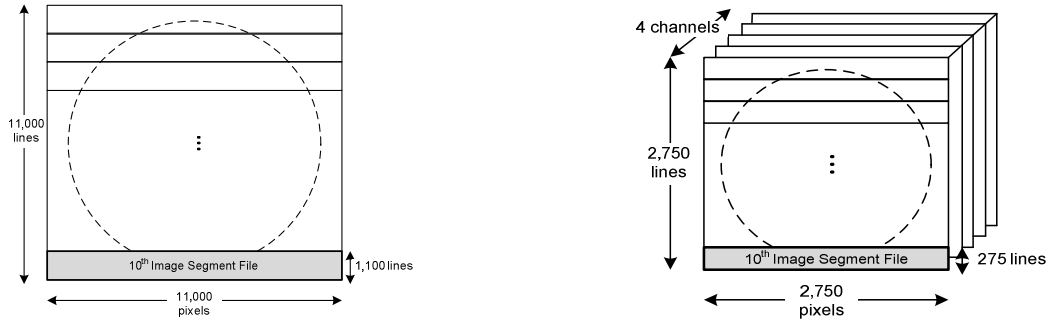


Figure 5 Segmentation of COMS HRIT Image (FD)

Table 3 Segment Information of COMS HRIT Images

Observation modes	Segment files	1 segment size	
		Visible channel	IR channels
FD	10	11,000 x 1,100	2,750 x 275
ENH	4	7,736 x 1,544	1,934 x 386
LSH	2	7,736 x 1,592	1,934 x 398
APNH	1	4,056 x 3,060	1,014 x 765

4.2 Structure of COMS HRIT File

Figure 6 shows the COMS HRIT file structure. An HRIT files consists of one or more header records and one data field. The primary header record defines the file type and the size of the complete HRIT file. The secondary header records include various information relating with the data field.

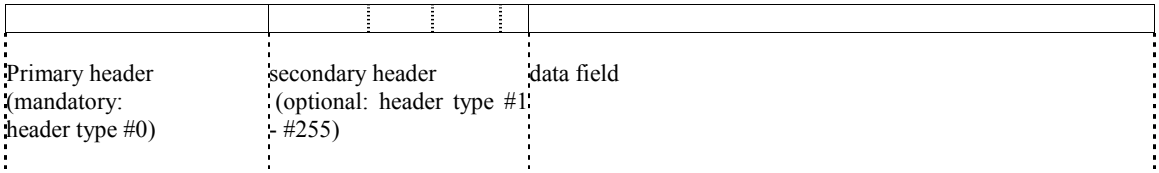


Figure 6 File Structure of COMS HRIT

4.3 File Type of COMS HRIT File

COMS HRIT file types are described in Table 4. The file types (0… 127) have already been defined in [AD 1]. In addition, the mission specific file types (128… 255) have been reserved for the future COMS HRIT service expansion.

Table 4 COMS HRIT File Type

File type code	File type	Application data type contained in the data field
Global HRIT types		
0	Image data	(normalized geostationary projection) - Full Earth's disk(FD) - Partial images : APNH , ENH, LSH
1	GTS message	(not used in the COMS HRIT mission) [RD 7]
2	Alpha-numeric text	Regular operational messages - Administrative messages including observation /dissemination timetables and newsletter
3	Encryption key message	Encrypted keys supporting COMS encryption scheme (not used in the COMS HRIT mission)
4 ... 127	Reserved	(for further global use)
Mission specific HRIT file type		
128 ... 255	Reserved	(for further mission specific use)

4.4 Header Records of COMS HRIT File

COMS HRIT header types are described in Table 5. The header types from #0 to #127 have already been defined in [AD 1] and remained header types from #128 to #255 are defined in COMS HRIT missions.

Table 5 COMS HRIT Header Type

Code	Header record type	Structure
Global header types		
0	Primary header	
1	Image structure	
2	Image navigation	
3	Image data function	
4	Annotation	
5	Time stamp	
6	Ancillary text	(not used)
7	Key header	
8 ... 127	Reserved for further global usage	(for further global usage)
Mission specific header types		
128	Image segment definition	Image segment file information
129	Encryption key message header	(not used)
130	Image compensation info. header	
131	Image observation time header	
132	Image quality info. header	
133 ... 255	Reserved	(for further mission specific use)

4.4.1 Header Type #0 – Primary Header

The structure of COMS HRIT header type #0 is described in Table 6. This header provides the size of total HRIT file(header records + data field). The padding data with the value of "0x00" will be filled at the end of data field to be line with 64 bits alignment of DES encryption when the encryption is applied

Table 6 Primary Header

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(not used)
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/ encryption of the data field

4.4.2 Header Type #1 - Image Structure

The structure of the COMS HRIT header type #1 is described in Table 7. This header provides number of bits per pixel (NB), number of columns (NC), number of lines (NL) of image structure, and compression flag.

Table 7 Image Structure

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 2 : Lossy compression

Explanations:

NB

The value of NB in COMS HRIT will be 10 bits for HRIT image

NC

The value of NC will be:

Visible channel image

FD: 11000
ENH: 7736
LSH: 7736
APNH: 4056

Infrared channel image

FD: 2750
ENH: 1934
LSH: 1934
APNH: 1014

NL

The value of NL will be the line number of one segment size:

Visible channel image

FD: 1100
ENH: 1544
LSH: 1592
APNH: 3060

Infrared channel image

FD: 275
ENH: 386
LSH: 398
APNH: 765

Compression_Flag

The value of flag will be 0 for no compression or 1 for lossless compression or 2 for lossy compression according the compression methods [RD 9].

4.4.3 Header Type #2 - Image Navigation

The structure of the COMS HRIT header type #2 is described in Table 8. This header provides the information of image projection on the earth.

Table 8 Image Navigation

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), projection names as defined in [AD 1] "GEOS(<sub_lon>)"
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]

Explanations:

Projection_Name is "GEOS(128.2)".

CFAC, LFAC, COFF, LOFF are identical for separate HRIT segment files.

Example values are as follows in case of FD,

Visible channel image

COFF = 5.50000000000E+03
CFAC = 4.09325140000E+07
LOFF = 5.50000000000E+03
LFAC = -4.09325140000E+07

Infrared channel image

COFF = 1.37500000000E+03
CFAC = 1.02331285000E+07
LOFF = 1.37500000000E+03
LFAC = -1.02331285000E+07

4.4.4 Header Type #3 - Image Data Function

The structure of the COMS HRIT header type #3 is described in Table 9. This header provides the physical meaning of the image data. It is used to define images which require establishing a relationship between their pixel count and physical units such as radiance/temperature or albedo.

Table 9 Image Data Function

Image Data Function record		
Header_Type	::=	unsigned integer (1byte), fixed value, set to 3
Header_Record_Length	::=	unsigned integer (2bytes), variable value, max. 65535
Data_Definition_Block	::=	character [ ], variable size and contents in accordance with [AD 1]

Explanations:

Data_Definition_Block

Example is a conversion table in piecewise linear format as follows ,

```
CHANNEL:=IR1
$HALFTONE:=16
_NAME:=INFRARED
_UNIT:=KELVIN
0:=330.06
30:=327.69
60:=325.29
89:=322.92
117:=320.60
144:=318.32
171:=316.01
197:=313.74
```

4.4.5 Header Type #4 – Annotation Text

The structure of the COMS HRIT header type #4 is described in Table 10. This header provides the annotation record to allow quicker and easier detection of file contents. Image data shall be satisfied with chapter 4.1 and other files are set up appropriately.

Table 10 Annotation

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

Explanations:

Annotation_Text

The file name of HRIT files is contained.

Examples are as follows,

IMG_APNH_01_IR1_20000912_061700_02.hrit	for image data
ADD_ANT_00_20000912_052500_00.hrit	for alphanumeric text
ADD_ENCMEG_00_20000912_052500_00.hrit	for encryption key message

Refer to section 4.5 for the formats of file name.

4.4.6 Header Type #5 – Time Stamp

The structure of the COMS HRIT header type #5 is described in Table 11. This header provides processing time in session layer.

Table 11 Time Stamp

Time Stamp Record		
Header_Type	::=	unsigned integer (1byte), fixed value, set to 5
Header_Record_Length	::=	unsigned integer (2bytes), fixed value, set to 10
CDS_P_Field	::=	unsigned integer (1byte), P-Field fixed value according to [RD 3] bit 0 (MSB) = '0' bits 1-3 = '100' bits 4-7 = '0000'
CDS_T_Field	::=	unsigned integer (6bytes) 6 octets T-field according to [RD 3]

Explanations:

According to CCSDS time format, the time code can be represented using Preamble (P) Field and Time Specification (T) Field. The P_Field defines the structure of T-Field and detailed information on the code.

CDS_P_Field

When bit 1-3 of P_Field is '100', it indicates that the time code is identified with CCSDS Binary Day Count Code (CDS).

CDS_T_Field

16 bits Contiguous day counter from 1 January 1958 starting with 0
32 bits Miliseconds of day
Submiliseconds segment is not used.

4.4.7 Header Type #6 – Ancillary Text

The header type #6 will be used for the COMS HRIT service expansion. .

4.4.8 Header Type #7 – Key Header

The structure of the COMS HRIT header type #7 is described in Table 12. This header provides the number of used encryption key.

Table 12 Key Header

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 encryption key

Explanations:

Key_Number

The key number of used encryption key is contained. The key numbers for user stations are managed by KMA(NMSC) and the key groups will be regenerated regularly for security.

This value is '00 00 00 00' when encryption is not applied.

4.4.9 Header Type #128 – Image Segmentation Identification

The structure of the COMS HRIT header type #128 is described in Table 13. This header provides information of the region for image-segmentation.

Table 13 Image Segment Identification

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 Image segment

Explanations:

Image_Segm_Seq_No

FD : 1 ~ 10 ENH : 1 ~ 4
LSH: 1 ~ 2 APNH: 1

Total_No_Image_Segm

FD : 10 ENH : 4
LSH: 2 APNH: 1

Line_No_Image_Segm

The first line number of the each segment
FD :
Visible channel(10 segments) : 1, 1101, 2201, 3301, 4401, 5501, 6601, 7701, 8801, 9901
Infraed channel(10 segments) : 1, 276, 551, 826, 1101, 1376, 1651, 1926, 2201, 2476
ENH :
Visible channel(10 segments) : 1, 1545, 3089, 4633
Infraed channel(10 segments) : 1, 387, 773, 1159
LSH :
Visible channel(10 segments) : 1, 1593
Infraed channel(10 segments) : 1, 399
APH :
Visible channel(10 segments) : 1
Infraed channel(10 segments) : 1

4.4.10 Header Type #129 – Encryption Key Message Header

Not used for COMS HRIT services.

4.4.11 Header Type #130 – Image compensation info. Header

COMS HRIT Header Type #130 is described in Table 14. This header includes the image navigation parameters, such as COFF, LOFF, CFAC, LFAC for the entire image data.

Table 14 Image Compensation info. Header

Image Compensation Info. Header Record		
Header_Type	::=	unsigned integer (1byte), fixed value, set to 130
Header_Record_Length	::=	unsigned integer (2bytes), variable value, max. 65535
Image_Compensation_Info	::=	character [ ], txt

Explanations:

CFAC, LFAC, COFF, and LOFF are identical for separate HRIT segment files.
Example values are as follows,
Visible channel image
COFF = 5.50000000000E+03
CFAC = 4.09325140000E+07
LOFF = 5.50000000000E+03
LFAC = -4.09325140000E+07
Infrared channel image
COFF = 1.37500000000E+03
CFAC = 1.02331285000E+07
LOFF = 1.37500000000E+03
LFAC = -1.02331285000E+07

4.4.12 Header Type #131 – Image observation time header

COMS HRIT Header Type #131 is described in Table 15. This header includes the observation time of image data as MJD (Modified Julian Day) format.

Table 15 Image Observation Time Header

Image Observation Time Header Record		
Header_Type	::=	unsigned integer (1byte), fixed value, set to 131
Header_Record_Length	::=	unsigned integer (2bytes), variable value, max. 65535
Image_Observation_Time	::=	character [ ], txt

Explanations:

Image_Observation_Time
Example values is as follows,
Ex) 52535.123456

4.4.13 Header Type #132 – Image quality information header

COMS HRIT Header Type # 132 is described in Table 16. This header represents Error pixel number of the whole image.

Table 16 Image Quality Info. Header

Image Quality Info. Header Record		
Header_Type	::=	unsigned integer (1byte), fixed value, set to 132
Header_Record_Length	::=	unsigned integer (2bytes), variable value, max. 65535
Image_Quality_Info	::=	character [ ], txt

Explanations:

Image_Quality_Info.
Ex) 1.02300000000E+03

4.5 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.

4.5.1 File Name of Image Data

The example of HRIT file name of image data is,
ex) IMG_FD_01_VIS_20000912_061700_09.hrit

The HRIT file name of image data is used as follows,

Table 17 HRIT file name of image data

	File type	Observation Mode	Sequence #	Spectral Channel	Dissemination Time	Segment File #	Extension
	IMG_	AB_	NN_	CH_	YYYYMMDD_hhmmss_	NN	.xrit
size	4 bytes (fixed)	Maximum 8 bytes	3 bytes (fixed)	Maximum 5 bytes	16 bytes (fixed)	2 bytes (fixed)	5bytes (fixed)
ex)	IMG_	FD_	01_	VIS_	20000912_061700_	09	.hrit

The observation mode can be one of followings,
: FD_
: APNH_
: ENH_
: LSH_

The sequence number has maximum two digits to indicate dissemination order of each observation mode a day.

The spectral channel can be one of followings,
: VIS_
: SWIR_
: WV_
: IR1_
: IR2

The segment file number can be determined according to the observation mode,
: 01 ~ 10 (FD)
: 01 ~ 04 (ENH)
: 01 ~ 02 (LSH)
: 01 (APNH)

4.5.2 File Name of Additional Data

The example of HRIT file name of additional data is,
ex) ADD_ENCMEG_00_20000912_052500_00.hrit

The HRIT file name of additional data is used as follows,

Table 18 HRIT file name of additional data

	File type	Abbreviation of Additional Data	Sequence #	Dissemination Time	Segment File #	Extension
	ADD_	AB _	NN_	YYYYMMDD_hhmmss_	NN	.xrit
size	4 bytes (fixed)	Maximum 8 bytes	3 bytes (fixed)	16 bytes(fixed)	2 bytes (fixed)	5bytes (fixed)
ex)	ADD_	ENHMEG _	00_	20000912_052500_	00	.hrit

The abbreviation of additional data can be one of followings,
: ANT_
: ENHMEG_

4.6 File Type vs. Header Implementation

Table defines the COMS HRIT mission specific use of header record types within certain HRIT file types.

Table 19 Use of Header Records vs. File Type

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: Alphanumeric text file	●				◎	◎		◎					
3: Encryption key message	●				◎	◎		◎					

● As requested by [AD 1] ◎ KMA mandatory use ○ KMA 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 info. header
131 Image observation time header
132 Image quality information header

5 SESSION LAYER

The session layer includes the definition of data compression and encryption for each HRIT data transmitted as file type from application layer. The output of the session layer to the transport layer is S_PDU containing the compressed and encrypted data field.

The session layer generates S_PDU by applying to each HRIT file from the presentation layer in the order of compression and encryption.

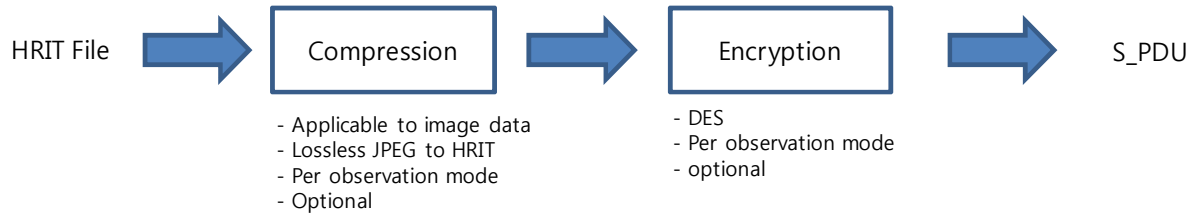


Figure 7 Session Layer Processing

The output is S_PDU containing the compressed and encrypted data field as shown in figure 8.

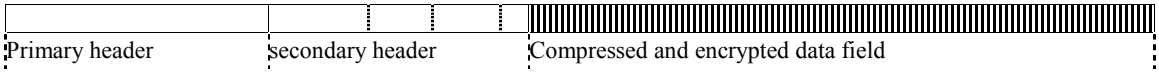


Figure 8 Session Layer Output (S_PDU)

5.1 JPEG Compression

ISO 10918 standard 'Digital compression and coding of continuous-tone still images' [RD 9] known as JPEG is chosen as the compression for the COMS HRIT service. It supports lossy and lossless schemes.

The Compression_Flag of Header_Type #1 is set to 0- 2 as below.

Header Type #1 - Compression_Flag of Image Structure

No compression: 0
JPEG lossless compression: 1
JPEG lossy compression: 2

5.2 DES Encryption

The encryption and decryption of COMS HRIT are based on a processing in accordance with the ECB (Electronic Code Book) mode of DES (Data Encryption Standard) [RD 10]. Figure 9 shows the principle of encryption and decryption.

The HRIT File is encrypted using an encryption master key managed by KMA(NMSC). The inverse process, decryption is also processed at MDUS at S/W level.

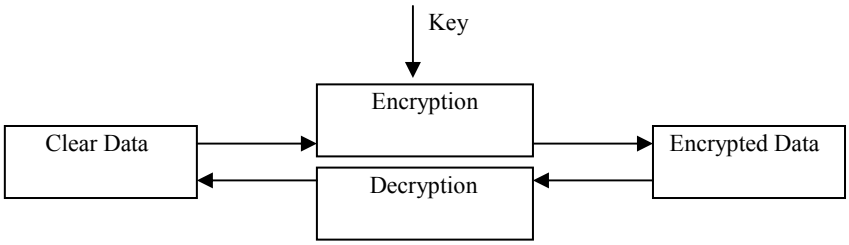


Figure 9 COMS HRIT DES Encryption

6 TRANSPORT LAYER

The transport layer generates TP_File with S_PDUs from session layer as byte unit and splits it into one or more CP_PDU with size of 8190 bytes. The CP_PDU is the CCSDS Path Protocol Data Unit [RD 2].

6.1 Transport File(TP_File)

In the transport layer, 10 byte TP_header is attached to the beginning of S_PDU and several bits (1~7) are filled at the end of S_PDU to make it in byte units. The structure of TP_File is shown in Figure 10 and TP_Header is described as bellows.

TP_Header		S_PDU	Filler
File Counter 16 bits	File Length 64 bits	1 ~ (2^{64}-1) bits	0~7 bits

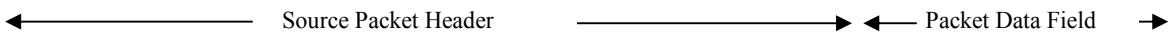
Figure 10 Transport File Structure

TP_Header (10 bytes)
File_Counter (2 bytes) :
VIS : 0 ~ 9
SWIR : 10 ~ 19
WV : 20 ~ 29
IR1 : 30 ~ 39
IR2 : 40 ~ 49
Others: 255
File_Length (8 bytes): file length [bits]

File_Counter is allocated in order to classify easily TP_File when processing them in the unit of file. As maximum number of COMS HRIT segment files is 10 files, 10 sequence numbers is allocated for each spectral band. Others counters are for the additional data.

6.2 Source Packet(CP_PDU)

The CP_PDU, output of the Transport Layer, is composed of Source Packet Header and Packet Data Field. The data field is composed of maximum 8190 bytes of TP_File and CRC. If the size of TP_File is not multiples of 8190 bytes, the length of last CP_PDU can be less than others. The structure of CP_PDU is shown in Figure 11.



Packet Identification				Packet Sequence Control		Packet Length	Data Field	
Version #	Type	Secondary Header Flag	APID	Sequence Flag	Packet Sequence Count		Application Data Field	CRC
3 bits	1 bit	1 bit	11 bit	2 bits	14 bits	16 bits	Var.	16 bits
2 octets				2 octets		2 octets	Max. 8190 octets	2 octets

Figure 11 Source Packet Structure

Source packet header is described as below.

Source Packet Header (6 bytes)
- Version (3 bits) : 0 (fixed)
- Type (1 bit) : 0 (fixed)
- Secondary Header Flag (1 bit) : 1 (include header)
  0 (not include header)
- APID (11 bits)
- Sequence Flag (2 bits) : 11 (single data)
  01 (first segment)
  00 (continued segment)
  10 (last segment)
- Packet Sequence Counter (14 bits)
- Packet Length (16 bits)

APID of COMS HRIT is defined as Table 20. **APID** is allocated to each channel of image data and additional. Fill packet is defined as 2047.

Table 20 APID of COMS HRIT

Application Process Identifier (APID)	Application
1024 : VIS 1056 : SWIR 1088 : WV 1120 : IR1 1152 : IR2 1184 : Alpha-numeric text 1216 : Encryption key message	COMS HRIT application data
1217 - 2015	Reserved for COMS HRIT service expansion
2016 - 2046	Reserved by CCSDS
2047	Fill Packets

Sequence Flag distinguishes each file and indicates file is composed of one packet or consecutive packet. In case of consecutive packet, **Sequence Flag** is able to distinguish first and middle, last packet.

Packet Sequence Counter calculates number of packet and reiterates from 0 to 16383. **Packet Length** is the value which subtracts 1 from the size of data right after header.

CRC attaching to the last part of CP_PDU is calculated by $g(x) = x^{16}+ x^{12}+x^5+1$ [AD 1].

7 NETWORK LAYER

The only function of Network Layer is to generate Virtual Channel ID (VCID) for each APID. According to [AD 1], the VCID is calculated by dividing APID by 32. The APIDs in Table 20 are mapped to VCIDs of Table 21. They are distributed between 0 ~ 62.

Table 21 VCID of COMS HRIT

Virtual Channel ID (VCID)	Application
32d : VIS 33d: SWIR 34d : WV 35d : IR1 36d : IR2 37d : Alphanumeric text 38d : Encryption key message	HRIT application data
63d	Fill Packets

The CP_PDU in Figure 11 is transparently routed as multiple CCSDS Packets (M_SDU) to the Data Link Layer.

8 DATA LINK LAYER

The data link layer of the CCSDS AOS space link is composed of following two sub-layers.
- Virtual channel link control (VCLC) sub-layer
- Virtual channel access (VCA) sub-layer

The VCLD sub-layer provides the multiplexing service based on the VCID from the Network Layer. It fills M_SDUs into multiplexing protocol data units (M_PDU).

The VCA sub-layer generates the virtual channel data units (VCDU) from M_PDUs and produces finally Channel Access Data Units (CADUs) by applying Reed-Solomon coding to control HRIT dissemination errors, data randomization, and attachment of synchronization marker. Fill VCDUs may have to generate for continuous data delivery to the lower layer.

The data link layer transfers CADUs to the physical layer.

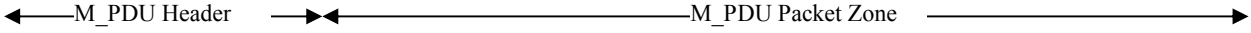
8.1 M_PDU

The M_PDU is composed of 884 bytes of multiple M_SDUs from the transport layer and 2 byte M_PDU Header. The M_PDU Header is defined as below.

M_PDU Header (2 bytes)
Spare (5 bits) : 0 (fixed)
First Header Point (11 bits)

First Header Point is the point which indicates the location of header of M_SDU. In case the consecutive M_SDUs are filled in the packet zone, it is 07FFh. Unless 07FFh, that means other M_SDU begins in the packet zone. When M_PDU has no more M_SDU, a fill packet is generated to complete the M_PDU in the size of 884 bytes. Refer to [RD 2] for fill packet generation.

The Structure of M_PDU is described in Figure 12 and the M_PDUs are passed to the VCA sub-layer service in (M_PDU, VCDU-ID).



Spare 5 bits	First Header Pointer 11 bit	End of M_SDU # (k-1)	M_SDU # (k)	M_SDU # (k+1)	…	Starting of M_SDU # (l)
2 octets		884 octets				

Figure 12 M_PDU Structure

8.2 VCDU

The M_PDUs are assembled in to VCDU according to [AD 1].
The VCDU structure is shown in Figure 13 and VCDU primary header is defined as below.

VC_Header (6 bytes)
Version_No (2 bits): 1 (fixed)
VCDU_ID

S/C ID (8 bits): C3h (11000011) [AD 3]
ID version for AOS (version 01: fixed)
VCID (6 bits): APID/32 (63d for Fill VCDUs)
VCDU Counter (24 bits)
Signal Field (7 bits): 0 (fixed)

VCDU Counter is the number of VCDU and reiterates from 0 to 16777215. **Signal Field** is not used and fixed in 0.

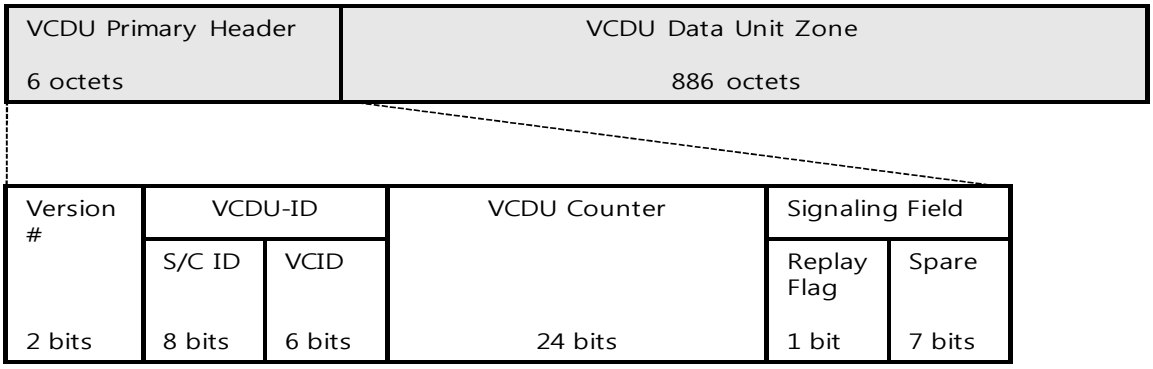


Figure 13 VCDU Structure

8.3 CVCDU

The CVCDU is formed with VCDU and the attachment of Reed-Solomon check symbols.
The Reed-Solomon (RS) code with an interleaving depth of 4 is applied to COMS HRIT services (255/223, 4). The RS code performs 64 bytes error detection and correction for CVCDU. The structure of CVCUD is shown in Figure 14.

Figure 14 CVCDU Structure

The randomization is applied to one CVCDU through the bitwise exclusive-OR process with the following polynomial to prevent random errors during HRIT transmission.

The pseudo-noise sequence is generated with this polynomial [AD 1],
$h(x) = x^8 + x^7 + x^5 + x^3 + 1$

8.4 CADU

The CADU is made of attachment of synchronization word (1ACFFCIDh') followed by randomized CVCDU. The structure of CADU is described in Figure 15.

Sync. Word	Randomized CVCDU
4 octets	1020 octets

Figure 15 CADU Structure

The packetized data rate of CADU level is less than 3Mbps (including 3Mbps).

9 PHYSICAL LAYER

The Physical Layer of COMS HRIT performs the convolution coding(r=1/2, K=7) of the serialized data stream and its modulation onto the RF up-link signal.
The COMS system follows basically the convolution coding of [RD 4], except symbol inversion on output path of G2.

The parameter sets of the physical layer are specified in the Table 22.

Table 22 Parameters of HRIT Communication Link

Parameters	Values
Downloading frequency	1695.4 MHz
Bandwidth	≤ 5.2 MHz
Information data rate*	3 Mbps
Satellite EIRP	26.79 dBm
Minimum G/T of ground antenna (MDUS)	11.1 dB/K
Maximum BER	10-8
Coding	Reed-Solomon (255/223, 4) and Convolution coding (1/2, K=7)
Pulse shaping	Root-Raised Cosine with 0.5 of roll-off factor
Polarization	Linear in East-West direction
Modulation	NRZ-L/QPSK
Length of one CADU	1024 bytes

* Information data rate is the HRIT CADU data rate prior to convolution encoding. Therefore, COMS HRIT transmission data rate is 6Mbps after convolution encoding.

APPENDIX A: COMS HRIT DATA STRUCTURE EACH LAYER

The Figure 16 describes the layer structure of COMS HRIT on the base of the data size.

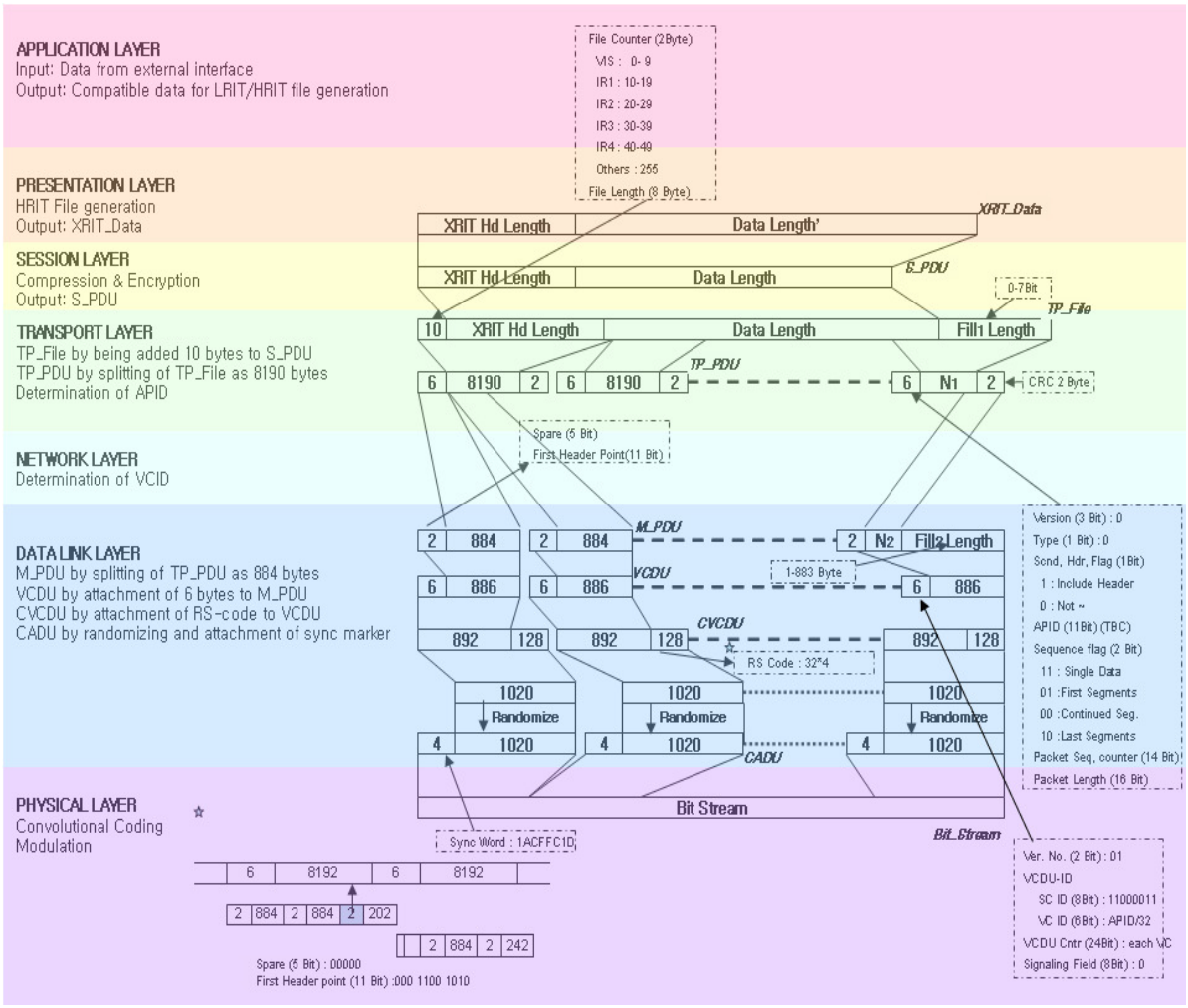


Figure 16 COMS HRIT Data Process of Each Layer

APPENDIX B (informative): CHANGE HISTORY

Change history			
Date	**Subject/Comment**	**Old**	**New**
May 30, 2008	New	-	1.0
Aug. 30, 2008	Change the structure of Chapter 4 Fix misprint in Chapter 9, Section 1.2 and Subsection 4.3.5, 4.4.2, 4.4.5	1.0	1.1
Nov. 30, 2010	Add detailed information of Header type #128 COMS HRIT Image Size was updated. Change the parameter of HRIT Communication Link(EIRP, Polarization) Add detailed information about convolution coding with viterbi decoding	1.1	1.2