

Communication, Ocean and Meteorological Satellite
COMS LRIT Mission Specific
Implementation



Keywords

< COMS, SDUS, LRIT >

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Foreword

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

Should the KMA modify the contents of the present document, it will be re-released by the 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 Low Rate Information Transmission (LRIT) is written in Co-ordination Group of Meteorological Satellites (CGMS), bases 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 LRIT files and the processing and the transport protocols of all OSI layers applicable to all geostationary meteorological spacecraft.

The purpose of this document, COMS LRIT Mission Specific Implementation, is the specification of the 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. This 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 LRIT Mission Specification' C1-SP-810-005 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] | 'Space packet protocol' CCSDS Recommendation 133.0-B-1, September 2003 |
| [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 LRIT Mission Specific Implementation' Issue 6, 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)
ENC	Encryption Process
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
LRIT	Low Rate Information Transmission
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 LRIT dissemination service is based on the Open Systems Interconnection (OSI) Reference Model in [RD 1] and the CCSDS AOS in [RD 2].

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

Table 1 OSI Layer Functionalities for the COMS LRIT Service

OSI 7 layers	Layer functionalities
Application layer	Acquisition of application data
Presentation layer	Image segmentation, LRIT 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/SDUS systems through the COMS LRIT dissemination services. Remained sections in this document will describe details of each layer in top-down direction in the corresponding chapter.

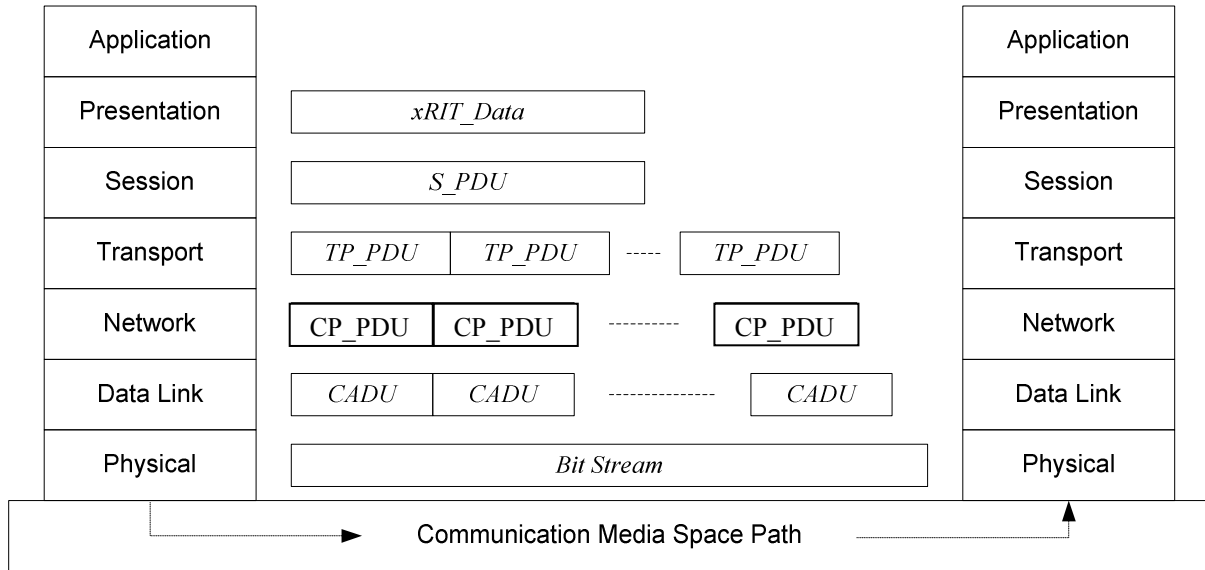


Figure 1 Definition of COMS LRIT Data Type

2.2 Data Dissemination

Transmission time of COMS LRIT is not bound to absolute time and the size of COMS LRIT is varied according to compression. The dissemination service will maintain in principle a regular, periodic distribution of the image data according to a priority scheme.

3 APPLICATION LAYER

3.1 Data Type

The COMS LRIT 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 file
- CMDPS analysis data
- Numerical weather product (NWP) model
- GOCI image data
- Typhoon information

3.1.1 Image Data

The type of image data consists of visible channel image, infrared channel image. The projection type of COMS LRIT is GEOS. The images defining latitude and longitude, size are distributed. Visible channel image and infrared channel image are serviced by same size in COMS LRIT. The size of image is specified on the assumption that sight of view angle is specified in [RD 5] and the size of full earth disk is 2200×2200. Data of the image is known by 4.4.3 Header Type #2 Image Navigation. The size of image is represented by width×height.

The image data of COMS LRIT has different spectral channels w.r.t the dissemination time; (visible, IR1, WV) for day time and (SWIR, IR1, WV) for night times. Every image is GEOS projection image at COMS geosynchronous orbit, 128.2 degrees east. The images of LRIT are 8-bit reduced resolution of MI images in the sub-sets of spectral bands and all observation modes. The image data in LRIT files is stored in little-endian byte orders.

Table 2 presents image sizes in each band and observation mode. The size of image is in order of width x height.

Table 2 Image Size in COMS LRIT Image Data

Observation modes	Visible/Infrared Channels
FD	2,200 x 2,200
ENH	1,547 x 1,234
LSH	1,547 x 636
APNH	810 x 611

3.1.1.1 FD Image

FD (Full Disk) image is normalized image of COMS satellite at geosynchronous orbit 128.2 degrees. The size of image is 2200×2200. Figure 2 is the observation area of FD image.



Figure 2 The observation area of FD Image

3.1.1.2 Regional Area Image

Regional area image consists of APNH, ENH and LSH.

3.1.1.3 APNH (Asia and Pacific in Northern Hemisphere) Image

APNH image is the image of Asia and Pacific in Northern Hemisphere. The size of image is 810×611 . Figure 3 is the observation area of APNH image.



Figure 3 The observation area of APNH Image

3.1.1.4 ENH (Extended Northern Hemisphere) Image

ENH image is the image of extended Northern Hemisphere. The size of image is 1547×1234 . Figure 4 is the observation area of ENH image.

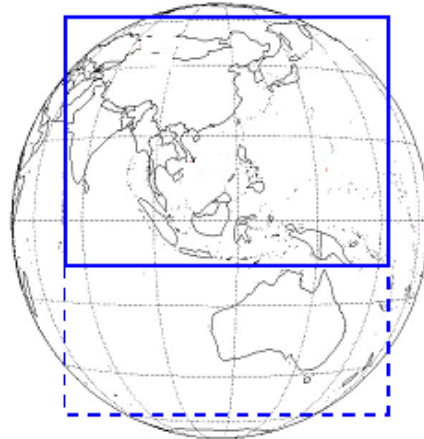


Figure 4 The observation area of ENH(Bold), LSH(Dotted Line) Image

3.1.1.5 LSH (Limited Southern Hemisphere) Image

LSH image is the image of Limited Southern Hemisphere. The size of image is 1547×636. Figure 4 is the observation area of LSH image.

3.1.2 Additional Data

Additional data of COMS LRIT includes alphanumeric text, meteorological data, CMDPS analysis data, GOCI data, binary data. Meteorological data consists of NEW data and typhoon information. The type of NWP data is information of pressure, temperature, wind, dew point deficit, stability, equivalent potential temperature.

Alphanumeric Text

The alphanumeric text is a service operational message such as MI observation schedule, its corresponding LRIT dissemination schedule, newsletters and coefficients/algorithms update information. This file can be based on text files or images according to the KMA's policy.

CMDPS analysis data

The sea surface temperature, fog, cloud information are disseminated through LRIT signal. The dissemination frequencies of each product are different from hourly to daily.

Numerical weather product (NWP) model

The atmospheric pressure, temperature, wind, atmospheric stability generated by KMA are disseminated twice a day in the format of GRIP or BURF.

GOCI image data

Another payload of the COMS, geostationary ocean color imager (GOCI), performs observation onto Korean peninsular ocean 10 times a day. The processed image data is disseminated to end-users through LRIT 8 times a day.

Typhoon information

The typhoon track prepared by KMA is disseminated twice a day in typhoon seasons. This file can be based on images.

4 PRESENTATION LAYER

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

4.1 Segmentation of COMS LRIT Image Data

It's necessary for LRIT image data to be divided for efficient LRIT generation processing. The numbering of the image segment files will follow the line direction. 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 LRIT FD image data is 2200 columns×220 lines because size of LRIT FD image data is 2200 columns×2200 lines and size of each segment is identical. Segmentation of LRIT FD Image is described in Figure 5.

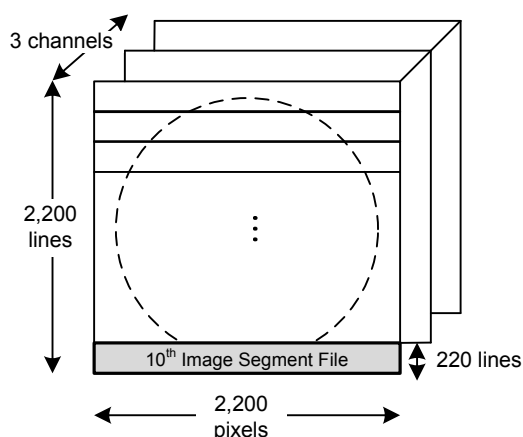


Figure 5 Segmentation of COMS LRIT Image (FD)

Table 3 presents image segment information of each observation mode. APNH image is not segmented.

Table 3 Segment Information of COMS LRIT Images

Observation modes	Segment files	1 segment size
		Visible/infrared channel
FD	10	2,000 x 200
ENH	4	1,547 x 309 (for 1 st , 2 nd) 1,547 x 308 (for 3 rd , 4 th)
LSH	2	1,547 x 318
APNH	1	810 x 611

4.2 File Structure

COMS LRIT files are formatted data as Figure 6. An LRIT file 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 LRIT file.

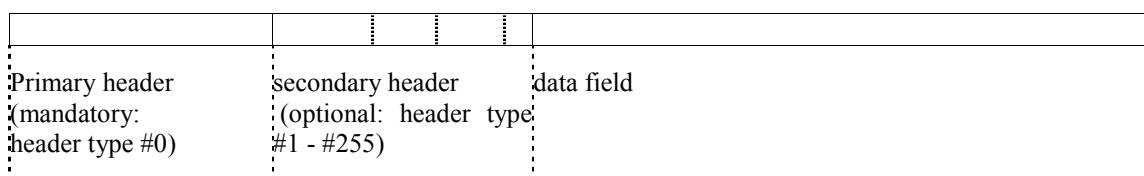


Figure 6 File Structure of COMS LRIT

4.3 COMS LRIT File Type

COMS LRIT file types are described in Table 4. The file types (0... 127) have already been defined in [AD 1]. In addition to, the mission specific file types (128... 255) are required for the COMS LRIT service to cover all data and information. Data of file type is inserted to header #0 of COMS LRIT.

Table 4 COMS LRIT File Type

File type code	File type	Application data type contained in the data field
Global LRIT file types		
0	Image data	(normalized geostationary projection) - Full Earth's disk - Partial images : APNH , ENH, LSH
1	GTS message	(not used in the COMS LRIT mission) [RD 7]
2	Alpha-numeric text	Regular operational messages - Administrative messages
3	Encryption key message	Encrypted keys supporting COMS encryption scheme (not used in the COMS LRIT mission)
4 ... 127	Reserved	(for further global use)
Mission specific LRIT file type		
128	CMDPS analysis data	Image data
129	NWP data	GRIB or BURF Edition 1 type
130	GOCI data	Image data
131	KMA typhoon information	Image data
132 ... 255	Reserved	(for further mission specific use)

4.4 COMS LRIT Header Type

COMS LRIT header types are described in Table 5. The file types from #0 to # 127 have already been defined in CGMS and the file types from # 128 to # 255 are defined in COMS LRIT. The headers #128 and #129 are allocated for information of image and encryption key.

Table 5 COMS LRIT Header Type

Code	Header record type	Structure
Headers as defined in LRIT Global Specification		
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)
Mission specific headers		
128	Image segment definition	Image segment file information
129	Encryption key message header	(not used)
130 ... 255	Reserved	(for further mission specific use)

4.4.1 Header Type #0 – Primary Header

The structure of the COMS LRIT header type #0 is described in Table 6. This header is required for all LRIT files and provides the size of total header and data and the type of file. **File_Type_Code** specifies the format of the data as defined in Table 6.

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, determining the top level structure of the file data field 0 : Image data file 1 : GTS Message 2 : Alphanumeric text file 3 : Encryption key message 128 : CMDPS analysis data 129 : NWP data 130 : GOCI data 131 : KMA typhoon information
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 LRIT 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 LRIT header type #1 is described in Table 7. This header determines the structure of the image and provides number of bits per pixel (NB), number of columns (NC), number of lines (NL), 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 Header_Type

Explanations:

NB

The value of NB will be 8 bits for LRIT image data.

NC

Visible channel image and Infrared channel image

- FD: 2,200
- ENH: 1,547
- LSH: 1,547
- APNH: 810

NL

Visible channel image and Infrared channel image

- FD: 200
- ENH: 309 or 308
- LSH: 318
- APNH: 611

Compression_Flag

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

4.4.3 Header Type #2 - Image Navigation

The structure of the COMS LRIT 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 LRIT segment files.

Example values are as follows in case of FD,,

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 LRIT 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 LRIT header type #4 is described in Table 10. This header provides the annotation record to allow more quick and easy detection of file contents. Image data shall be satisfied with chapter 4.1 and other files are set up appropriately. Those lengths are less than 67 Byte.

Table 10 Annotation

Image Data Function 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 LRIT files is contained.

Examples are as follows,

IMG_APNH_01_IR1_20000912_061700.lrit	for image data
ADD_AMV_00_20000912_052500_00.lrit	for alphanumeric text
ADD_ENCMEG_00_20000912_052500_00.lrit	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 LRIT 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	Milliseconds 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 LRIT service expansion.

4.4.8 Header Type #7 – Key Header

The structure of the COMS LRIT 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 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 LRIT 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

FD (10 segments): 1, 221, 441, 661, 881, 1101, 1321, 1541, 1761, 1981
 ENH (4 segments): 1, 310, 619, 927
 LSH (2 segments): 1, 319
 APNH: 1

4.4.10 Header Type #129 – Encryption Key Message Header

Not used for COMS LRIT services.

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 LRIT is defined as follows.

4.5.1 File Type

The example of LRIT file name of image data is,

ex) IMG_FD_01_VIS_20000912_061700_03.LRIT

The LRIT file name of image data is used in Table 14.

Table 14 The LRIT 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	03	.lrit

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 LRIT file name of additional data is,

ex) ADD_ENCMEG_00_20000912_052500_00.LRIT

The LRIT file name of additional data is used in Table 15.

Table 15 The LRIT 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	.lrit

The abbreviation of additional data can be one of followings,

- : ANT_
- : ENHMEG_
- : AMV
- : NWP_
- : GOCI_
- : TYP_

4.6 File Type vs. Header Implementation

Table 6 defines the COMS LRIT mission specific use of header record types within certain LRIT file types.

Table 16 Use of Header Records vs. File Type

File types	Header record types									
	0	1	2	3	4	5	6	7	128	
0: Image data file	●	●	◎	◎	◎	◎		◎	◎	
2: Alphanumeric text file	●				◎	◎		◎		
3: Encryption key message	●				◎	◎		◎		
128: CMDPS analysis data	●				◎	◎		◎		
129: NWP data	●				◎	◎		◎		
130: GOCI image data	●				◎	◎		◎		
131: typhoon information	●				◎	◎		◎		

- As requested by [AD 1] ◎ KMA mandatory use ○ KMA optional use

- | | |
|--|---|
| <ul style="list-style-type: none"> 0 Primary header 1 Image structure 2 Image navigation 3 Image data function 4 Annotation 5 Time stamp 6 Ancillary text | <ul style="list-style-type: none"> 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 generates S_PDU by applying to each LRIT file from the Presentation Layer in the order of compression and encryption.

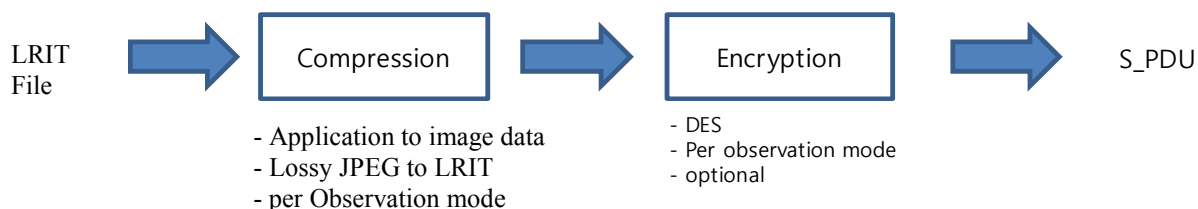


Figure 7 Session Layer Processing

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



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

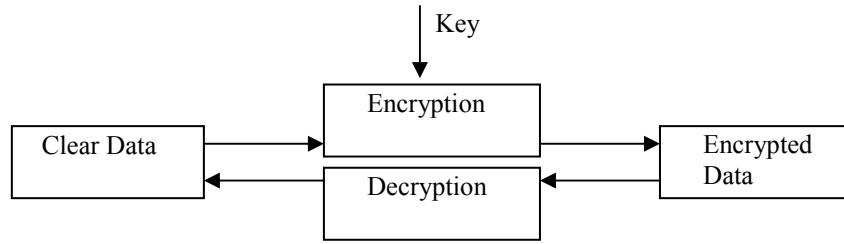


Figure 9 COMS LRIT DES Encryption

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 below.

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

Figure 10 Transport File Structure

TF_Header (10 Byte)

File_Counter (2 Byte)

VIS: 0 - 9

SWIR: 10 -19

WV: 20 - 29

IR1: 30 - 39

IR2: 40 - 49

Others: 255

File_Length (8 Byte): file length [Bit]

File_Counter is allocated in order to classify easily TP_File when processing them in the unit of file. As maximum number of COMS LRIT segment files are 10 files, 10 sequence numbers are 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.

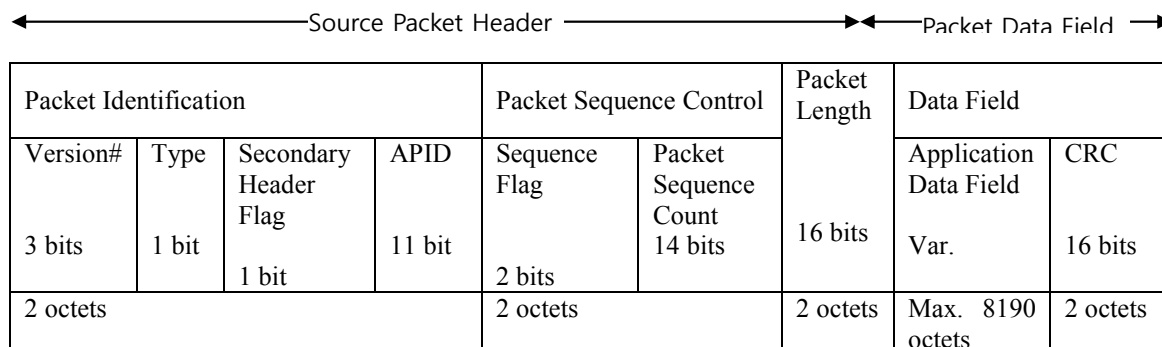


Figure 11 Source Packet Structure

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 LRIT is defined as Table 17. **APID** is allocated to each channel of image data and additional. Fill packet is defined as 2047.

Table 17 APID of COMS LRIT

Application Process Identifier (APID)	Application
0 : VIS 32: SWIR 64 : WV 96 : IR1 128 : IR2 160 : Alpha-numeric text 192 : Encryption key message 224: CMDPS analysis data 256 : NWP data 288 : GOCI data 320 : Binary data 352 : Typhoon information	COMS LRIT application data
353 ~ 2015	Reserved for COMS LRIT 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 17 are mapped to VCIDs of Table 18. They are distributed between 0 ~ 62.

Table 18 VCID of COMS LRIT

Virtual Channel ID (VCID)	Application
0d : VIS 1d : SWIR 2d : WV 3d : IR1 4d : IR2 5d : Alphanumeric text 6d : Encryption key message 7d : CMDPS analysis data 8d : NWP data 9d : GOCI data 10d : Binary data 11d : Typhoon information	COMS LRIT 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 VCLC 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 LRIT 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 with 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 section of 5.3.8.2.2.3 [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).

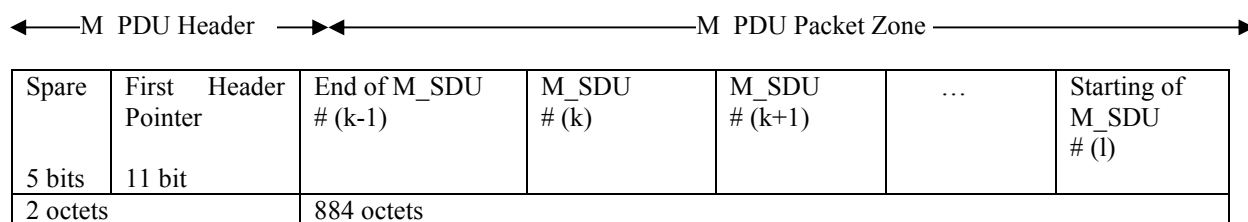


Figure 12 M_PDU Structure

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.

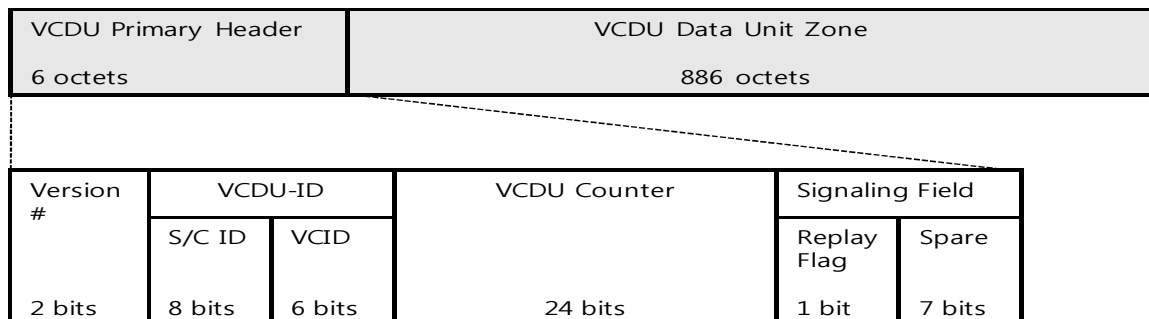


Figure 13 VCDU Structure

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 LRIT services (255/223, 4). The RS code performs 64 bytes error detection and correction for CVCDU. The structure of CVCDU 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 LRIT 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.

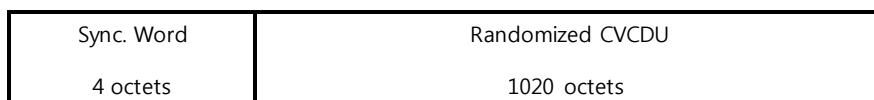


Figure 15 CADU Structure

The packetized data rate of CADU level is less than 256Kbps (including 256Kbps).

9 PHYSICAL LAYER

The Physical Layer of COMS LRIT 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 19.

Table 19 Parameters of LRIT Communication Link

Parameters	Values
Downloading center frequency	1692.14 MHz
Bandwidth	≤ 1 MHz
Maximum Information data rate*	256 kbps
Satellite EIRP	27.28 dBm
Minimum G/T of ground antenna (SDUS)	1.9 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/BPSK
Length of one CADU	1024 bytes

* Information data rate is the LRIT CADU data rate prior to convolution encoding. The data rate is maximum value.

APPENDIX A: COMS LRIT DATA STRUCTURE

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

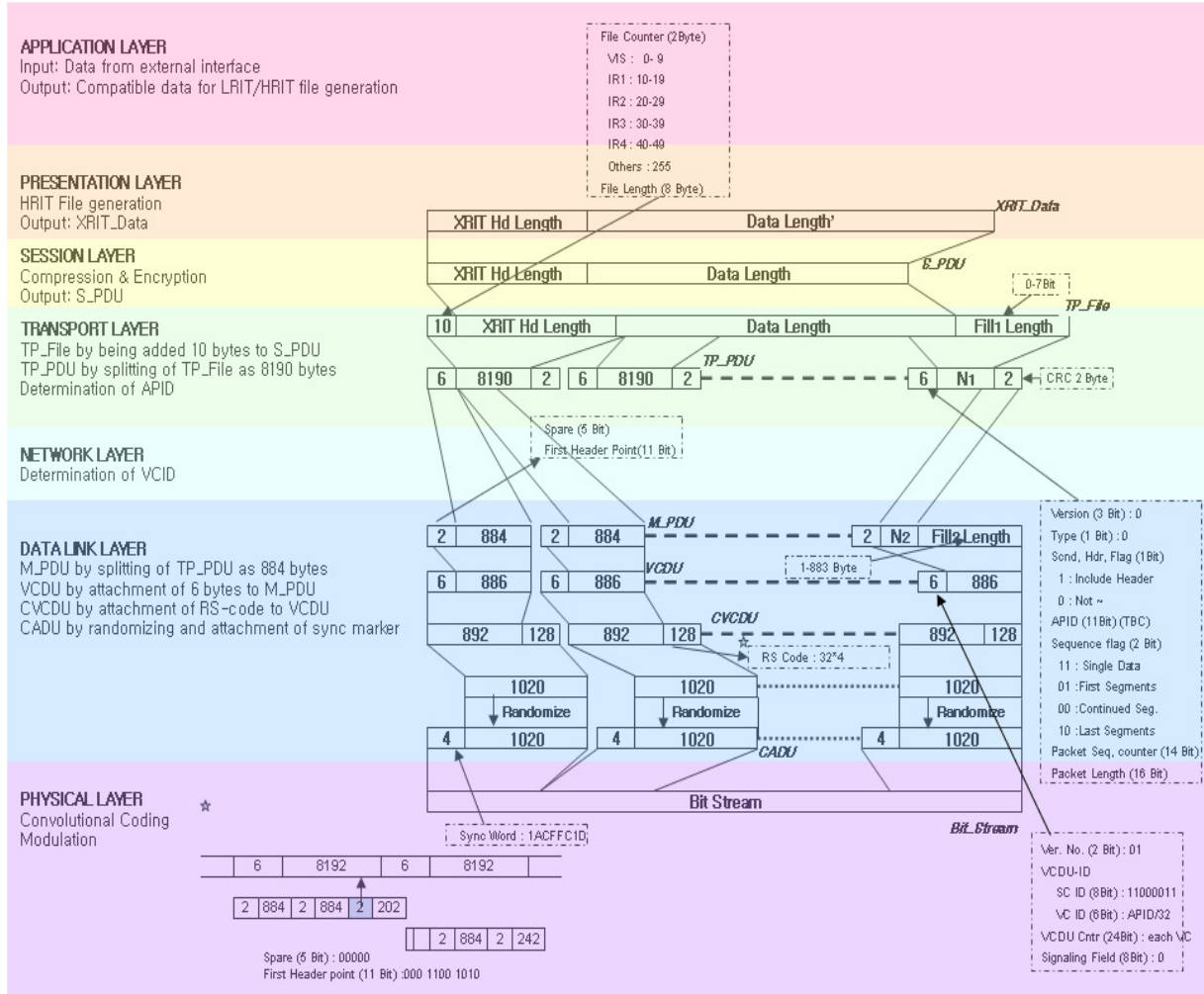


Figure 16 COMS LRIT Data Process of Each Layer

APPENDIX B: LRIT Ancillary Data

Table 20 LRIT Ancillary Data

Service	Type	Contents	Dissemination Period	Format
Meteorological Data	NWP Data	Pressure	2/day (00,12 UTC)	GRIB or BURF
		Temperature		
		Wind		
		Dew-point deficit		
		Stability		
	Equivalent potential temperature			
	Typhoon information	KMA Typhoon track prediction	2/day (in case of typhoon)	Image
Satellite Analysis Data	CMDPS Analysis Data	Sea surface temperature	2/day (1day/5 day average)	Image
		Fog	1 hour	Image
		AMV (Atmospheric motion vector)	8/day (every 3 hours)	ASCII or Binary
		Cloud information	4/day (every 6 hours)	Image
GOCI Image	Image	Chlorophyll	8/day	Image
		Suspended solids	8/day	
		Dissolved organic matter	8/day	
Information for LRIT	Alphanumeric text	LRIT service message	1/day	ASCII

APPENDIX C (informative): CHANGE HISTORY

Change history			
Date	Subject/Comment	Old	New
Aug. 30, 2008	New	-	1.0
Mar. 31, 2009	Header type #6 is not used	1.0	1.1
Nov. 30, 2010	COMS LRIT Image Size was updated. Change the parameter of LRIT Communication Link(maximum information data rate , EIRP, Polarization) Add detailed information about convolution coding with viterbi decoding	1.1	1.2