RUSSIAN FEDERAL SERVICE ON HYDROMETEOROLOGY
STATE RESEARCH INSTITUTE ON SPACE HYDROMETEOROLOGY PLANETA

ELECTRO-L GROUND SEGMENT
MSU-GS INSTRUMENT

LRIT/HRIT Mission Specific Implementation

Version: 1.0

Date: February 2012.

Moscow

Table of contents

1 INTRODUCTION

The purpose of this document is the specification of the more detailed communication structure of LRIT/HRIT format applied to the dissemination service of the Electro –L #1 geostationary meteorological satellite. Main structure and formats of data are conform to «MSG Ground Segment LRIT/HRIT Mission, Specific Implementation, Doc. No: EUM/MSG/SPE/057, Issue: 6, Date: 21 June 2006».

This allows using the same software packets as for MSG missions.

Level 1.5 image data corresponds to the geolocated and radiometrically pre-processed image data, ready for further processing, e.g. the extraction of meteorological products.

The complete earth's disk image data will be divided into segments. Each of them forms a separate LRIT/HRIT file.They will contain a fixed number of lines.

As a baseline, all image segment files provided via LRIT/HRIT will contain 464 lines.

The complete Earth’s disk of Electro-L MSU-GS radiometer level 1.5 images will have a size of 11136×11136 pixel for the HRV channel and 2784×2784 pixel for other 10 channels.

With an image segmentation size of 464 lines, one complete Earth image will consist of 24 image segment files in the HRV channel (464 lines of 11136 pixels), and 6 image segment files for any other spectral channel (464 lines of 2784 pixel).

Electro-L forms in HRIT mode images of the Earth in 10 different spectral channels, from visible to infrared, with nominal on-ground pixel resolution of 4 km at Sub Satellite Point with 10 bit per pixel sampling. It also has one High Resolution Visible (HRV) channel with1 km resolution at Sub Satellite Point with 10 bit per pixel sampling.

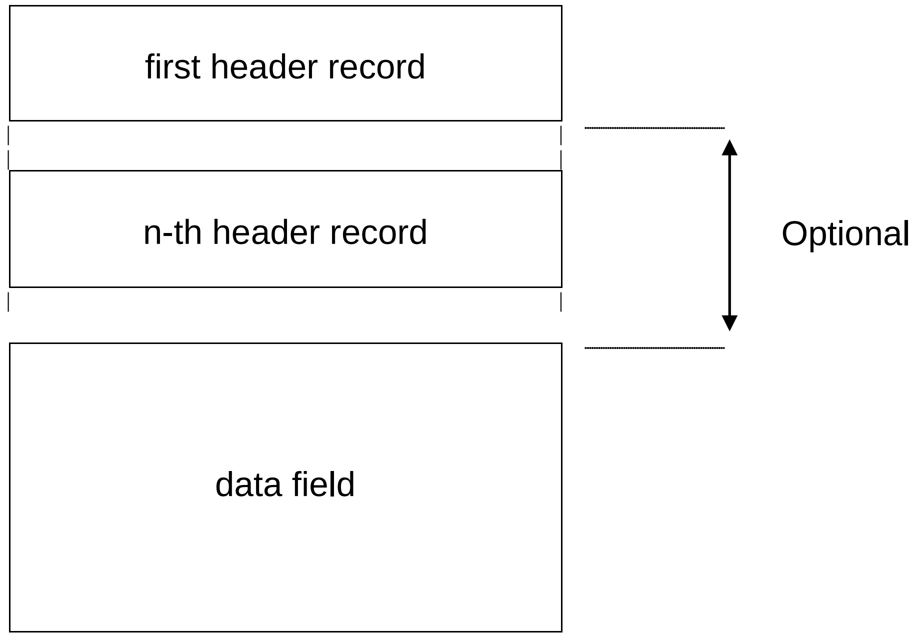
In LRIT mode it forms some of spectral channels 2784×2784 pixel with nominal on-ground pixel resolution of 4 km at Sub Satellite Point with 8-bit per pixel sampling.

2 STRUCTURE OF LRIT/HRIT FILES

Each application data unit to be distributed via Electro-L dissemination will be formatted to an LRIT/HRIT file. An LRIT/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 sizing of the complete LRIT/HRIT file. Depending on the file type, one or more secondary headers may be required to provide ancillary file information.

The file type number identifies the data contained in the data field. The global definitions of file types from #0 to #127 are defined in [AD.1]. Mission specific file type extensions are all file types from #128 and #255. For Electro-L, two additional file types (#128, #129) are specified. The description of LRIT/HRIT files and their data fields is contained in sect. 4.2.



Primary header #0	secondary header records (#1 - #127) according to [AD.1]	secondary header records (#128 - #255) as defined in sect. 4.3	data field

Figure 1 – LRIT/HRIT File Structure

3 LRIT/HRIT FILE TYPES AND DATA FIELD DESCRIPTIONS

3.1 LRIT/HRIT File Types Overview

The ‘global’ file types (0 ... 127) are defined in [AD.1]. In addition, the mission specific file types (128 ... 129) are required for the Electro-L dissemination service to cover all data and information to be provided via the LRIT/HRIT dissemination. The file types (130 ... 255) are available for future expansion.

Table 2 specifies the ‘spread’ of all data types identified and described in previous sections over the various LRIT/HRIT file types.

file type code	file type	Application data types/subtypes contained in the data field
Global LRIT/HRIT file types		
0	Image Data	Image data segments as described in sect. 4.2.2
1 ... 127	Reserved	(for further global usage)
Mission specific LRIT/HRIT file types		
128	Repeat Cycle Prologue	This file type provides additional information about the satellite/ image processing status known at the start of a MSU-GS level 1.5 data
129	Repeat Cycle Epilogue	This file type contains status information known at the end of a repeat cycle of MSU-GS level 1.5 data.
130 ... 255	Reserved	(for further mission specific use)

Table 2 - LRIT/HRIT File Types

3.2 File Type #0 - Image Data

File type #0 will be used for all MSU-GS level 1.5 imagery data The LRIT/HRIT data field of file type #0 contains bitmap data in accordance with the specifications in [AD.1]. The dissemination via Electro-L will only distribute images of a pixel resolution of 8 or 10 bit per pixel.

Due to the timeliness requirement, the image data files will only contain image segments.

The file type #0 may contain compressed data. Further information about the algorithms applied to the image data content due to data compression can be found in Section 5 (session layer processing).

3.3 File Type #128 - Repeat Cycle Prologue

The Repeat Cycle Prologue will be disseminated before or at an early stage of a repeat cycle of MSU-GS L1.5 images. These include files of type #0. The repeat cycle prologue will contain information about the satellite status and/or the image processing known at the start of that particular repeat cycle. The Repeat Cycle Prologue files will not be segmented.

The data field of the Repeat Cycle Prologue for MSU-GS 1.5 will contain the following subset of HEADER records:

- SatelliteStatus
- ImageAcquisition

ImageCalibration

For MSU-GS Level 1.5 images, the repeat cycle will also include a repeat cycle epilogue (file type #129, see Section 4.2.7).

SatelliteStatus

Title: SatelliteStatus

SatelliteStatus	::=	RECORD
{ TagType		UNSIGNED DWORD
TagLength		UNSIGNED DWORD
SatelliteID		UNSIGNED DOUBLE
SatelliteName		CHARACTERSTRING SIZE (**256**)
NominalLongitude		REAL DOUBLE
SatelliteCondition		UNSIGNED DWORD { operational (1), standby (1), commissioning/test (2), manoeuvre (3)}
TimeOffset		REAL DOUBLE
}		

Table 3

Explanations:

- TagType – UFD_TAG_ SatelliteStatus = 2
- TagLength – Length in octets;
- SatelliteID – Identification;
- SatelliteName – Name of the satellite (GOMS-1);
- NominalLongitude – Nominal longitude at Sub Satellite Point in radians;
- SatelliteCondition – Status of satellite (operational, standby, test, etc.);
- TimeOffset – information required to relate the On-Board Time to the Universal Time Coordinated (UTC).

ImageAcquisition

Title: ImageAcquisition

```
ImageAcquisition          ::=  ARRAY SIZE (1..10) OF
                               RECORD
{ TagType                      UNSIGNED DWORD
  TagLength                    UNSIGNED DWORD
  Status                       UNSIGNED DWORD
  StartDelay                   INTEGER
  Cel                          REAL DOUBLE
}
```

Table 4

Explanations:

- TagType – UFD_TAG_ImageAcquisition = 3;
- TagLength – Length in octets;
- Status – Status indicators for all channels and all detectors of the radiometer, showing which are switched on/off within the MSU-GS instrument;
- StartDelay – difference between scan start time for given group of channels and RepeatCycleStart time in microseconds;
- Cel – fraction of bad scan lines, if < 0, then parameter is not available.

ImageCalibration

Title: ImageCalibration

```
ImageCalibration          ::=  ARRAY SIZE (1..10) OF
                                    ARRAY SIZE (1..1024) OF   INTEGER
```

Explanations:

For each of 10 spectral channels a table of 1024 elements is formed. It is used to relate the Level 1.5 image pixel count values to physical radiance unit (for visual channels) or to radiance temperatures in Kelvin (for IR). Functional dependence t (physical radiance) of g (table content code) is $t = g / 1000$.

3.4 File Type #129 - Repeat Cycle Epilogue

Level 1.5 Trailer Summary

The purpose of the **trailer** which accompanies each Level 1.5 image is also to supply ancillary information needed by the end-user for interpreting the data and / or further processing the image.

In contrast to the header, the trailer contains information which is either accumulated during the processing of the image, or at its completion, and is generated at the end of the image repeat cycle, following the image data.

The trailer comprises a number of component items which hold information relevant to the topics indicated below:

RadiometricProcessing –

GeometricProcessing -

Title: RadiometricProcessing

```
RadiometricProcessing          ::=   ARRAY SIZE (1..10) OF
                                     RECORD
{ TagType                            UNSIGNED DWORD
  TagLength                          UNSIGNED DWORD
    RPSummary                        RECORD
    {
     Impulse                         UNSIGNED DWORD
     IsStrNoiseCorrection            UNSIGNED DWORD
     IsOptic                         UNSIGNED DWORD
     IsBrightnessAligment}           UNSIGNED DWORD
   OpticCorrection                   RECORD
   {
      Degree                         INTEGER
      A}                             REAL DOUBLE SIZE(16)
  RPQuality                          RECORD
   {
     EffDinRange                     REAL DOUBLE
     EathDarkening                   REAL DOUBLE
     Zone                            REAL DOUBLE
     Impulse                         REAL DOUBLE
     Group                           REAL DOUBLE
     DefectCount                     UNSIGNED DWORD
     DefectProcent                   REAL DOUBLE
     S_Noise_DT_Preflight            REAL DOUBLE
     S_Noise_DT_Bort                 REAL DOUBLE
     S_Noise_DT_Video                REAL DOUBLE
     S_Noise_DT_1_5                  REAL DOUBLE
     CalibrStability                 REAL DOUBLE
     TemnSKO                         REAL DOUBLE SIZE(2)
     StructSKO                       REAL DOUBLE SIZE(2)
      Struct_1_5                     REAL DOUBLE
      Zone_1_ 5                      REAL DOUBLE
      RadDif}                        REAL DOUBLE
}
```

Explanations:

TagType – UFD_TAG_ RadiometricProcessing = 4;

TagLength – Length in octets;

RPSummary – Record containing summarised details of radiometric processing per radiometer channel, indicating whether or not various aspects of radiometric processing have been applied or not to the data for each of the channels:

Impulse - indicates applying single and group channel error correction to the data (1 – correction applied, else – error code);

IsStrNoiseCorrection - indicates applying correction of structural distortion in channel (1 – statistic method correction applied, 2 – calibration method correction applied, 3 – onboard correction applied, else – error code);

IsOptic - indicates correction of zonal characteristics (1 – statistical correction, 2 – calibration correction, 3 – onboard correction, other – error code);

IsBrightnessAligment - indicates if brightness alignment was performed for overlapping CCD sensors, visible band (1 – alignment performed, other – error code);

OpticCorrection – record containing coefficients for zonal characteristic correction:

Degree – a degree of correcting polynomial;

A - an array of polynomial coefficients;

RPQuality – record containing information about radiometric quality of the data and quality of radiometric correction (negative values if not calculated):

EffDinRange – dynamic range effective usage;

EathDarkening - index of the Earth darkening in the channel;

Zone - zonal distortion degree for the channel;

Impulse – amount of impulse noise for the channel;

Group - group interference degree for the channel;

DefectCount - number of failed CCD sensor elements for the channel;

DefectProcent - persent of failed CCD sensor elements for the channel;

S_Noise_DT_Preflight – S/N ratio for visible band and NEΔT for the IR band (pre-flight calibration data);

S_Noise_DT_Bort - S/N ratio for visible band and NEΔT for the IR band (onboard calibration data);

S_Noise_DT_Video - S/N ratio for visible band and NEΔT for the IR band (based on visible channel data);

S_Noise_DT_1_5 - S/N ratio for visible band and NEΔT for the IR band (based on normalized visible channel data);

CalibrStability - onboard calibration data stability;

TemnSKO - fluctuation of dark noise for two sensors in visible band only;

StructSKO - fluctuation of CCD sensor elements sensitivity;

Struct_1_5 - residual structural distortion in channel;

Zone_1_ 5(double) - residual structural median brightness distortion in channel for whole image field;

RadDif - residual brightness differences for overlapping CCD sensors (visible channels only);

GeometricProcessing – geometric processing information (Type = **UFD_TAG_GeometricProcessing** = 5):

Explanation:

TagType – tag type;

TagLength – length in bytes;

Title: GeometricProcessing

```
GeometricProcessing          ::=   ARRAY SIZE (1..10) OF
                                    RECORD
{ TagType                           UNSIGNED DWORD
   TagLength                        UNSIGNED DWORD
   TagChGroup                       UNSIGNED DWORD
    TGeomNormInfo                   RECORD
    {
     IsExist                        UNSIGNED DWORD
     IsNorm                         UNSIGNED DWORD
     SubLon                         REAL DOUBLE
     TypeProjection                 UNSIGNED DWORD
     PixInfo}                       REAL DOUBLE SIZE(4)
   SatInfo                          RECORD
    {
     TISO                           RECORD
      {
       T0                           REAL DOUBLE
       dT                           REAL DOUBLE
       ASb                          REAL DOUBLE
       Evsk                         REAL DOUBLE
                                    SIZE(3)(3)(4)
       ARx                          REAL DOUBLE SIZE(4)
       ARy                          REAL DOUBLE SIZE(4)
       ARz                          REAL DOUBLE SIZE(4)
       AVx                          REAL DOUBLE SIZE(4)
       AVy                          REAL DOUBLE SIZE(4)
       AVz}                         REAL DOUBLE SIZE(4)
    Type}                           INTEGER
    TimeProcessing                  REAL DOUBLE
    AprioAccuracy                   REAL DOUBLE
    RelativeAccuracy                REAL DOUBLE SIZE(2)
}
```

TGeomNormInfo – geometric normalization record:

IsExist – a flag for existing the resulting image in the channel (1 – normalized image exists, 0 – image was not generated);

IsNorm – 0 if normalization performed, or error code;

SubLon – satellite longitude in normalized geostationary projection, radians;

TypeProjection - projection type (1 – normalized geostationary projection).

PixInfo – coefficient set for pixel-to-geostationary projection transformation.

SatInfo – satellite position and orientation data, geodetic connection method (maps, Earth disk or telemetry data):

TISO – auxiliary information used for geometric normalization:

T0 – onboard start interpolation time;

dT – interpolation spacing period;

ASb – solar panel angle;

Evsk – orientation matrix approximation coefficients to global coordinate system;

ARx, ARy, ARz – approximation coefficients satellite position vector to global coordinate system

AVx, AVy, AVz – approximation coefficients of satellite speed vector to global coordinate system

Type – geodetic connection method (1 – telemetry data, 2 – Earth disk, 3 - maps);

TimeProcessing - image processing time.

ApriorAccuracy - *a priori* accuracy for level 1.0 data gridding with orbital data .

RelativeAccuracy – relative accuracy of data gridding for up to 16 and 500 elements (all channels).

Epilogue files are not segmented.

4 TAG TYPES FOR LRIT/HRIT HEADER

4.1 Summary

Header tag types are described below:.

Table 2. LRIT/HRIT header types

Code	Header record type
Tags from LRIT/HRIT Global Specification	
0	Primary header
1	Image structure
2	Image navigation
3	Image data function
4	Annotation
5…127	Not used
128	Segment identification
129	Image segment line quality
130…255	Not used

4.2 Definition of Header Types

4.2.1 Header Type #0 - Primary Header

The structure of the primary header record is defined as:

Title: Primary Header Record		**Id: PRIMARY HEADER**	
PRIMARY HEADER	::	RECORD	
{ Header_Type		UNSIGNED BYTE (**0**)	-- fixed value
Header_Record_Length		UNSIGNED SHORT (**16**)	-- fixed value
File_Type_Code		ENUMERATED BYTE {image data file (0), prologue (128), epilogue (129)}	-- defines file type
Total_Header_Length		UNSIGNED	variable specifies total size of all header records.
Data_Field_Length		UNSIGNED DOUBLE	-- specifies total size of the LRIT/HRIT file data field in bits. For image data files, this parameter will be completed after compression of the data field.
}			

Explanations:

• File_Type_Code

The File_Type_Code specifies the formatting of the data to be transmitted via LRIT/HRIT files.

4.2.2 Header Type #1 - Image Structure

Mandatory for video data. The structure of the image structure record is defined as:

Title: Image Structure Record		**Id: IMAGE_STRUCTURE**	
IMAGE_STRUCTU	::=	RECORD	
{ Header_Type		UNSIGNED BYTE (**1**)	-- fixed value
Header_Record_Length		UNSIGNED SHORT (**9**)	-- fixed value
NB		UNSIGNED BYTE	-- number of bits per pixel
NC		UNSIGNED SHORT	-- number of columns
NL		UNSIGNED SHORT	-- number of lines
Compression_Flag		ENUMERATED BYTE { no compression (0), lossless compression (1), lossy compression (2)}	-- compression method
}			

Explanations:

• NB (number of bits per pixel)

The value for NB will be either 8 or 10 bit/pixel

• NC (number of columns)

The value for NC will be:

11136	For visible channels with spatial resolution 1 km
2784	For all channels with spatial resolution 4 km
any multiple of 464 (baseline segment value)	for other image data

• Compression_Flag

The Compression_Flag defines the compression method (lossless or lossy). The applicable compression algorithm and its inherent data representation is defined by the Data_Representation field of the header type #128.

4.2.3 Header Type #2 - Image Navigation

This tag defined Earth image projection. The structure of the image navigation record is defined as:

Title: Image Navigation Record		**Id: IMAGE_NAVIGATION**	
IMAGE_NAVIGATION	::=	RECORD	
{ Header_Type		UNSIGNED BYTE (**2**)	-- fixed value
Header_Record_Length		UNSIGNED SHORT (**51**)	-- fixed value
Projection_Name		CHARACTERSTRING SIZE (**32**) {“GEOS(<sub_lon>)” }	-- projection names
CFAC		INTEGER	-- column scaling factor
LFAC		INTEGER	-- line scaling factor
COFF		INTEGER	-- column offset
LOFF		INTEGER	-- line offset
}			

Explanations:

Projection_Name – normalized geostationary projection

CFAC / LFAC

The column and line scaling factors (CFAC and LFAC) contain variable values which depend on
the input data and their specific segmentation approach..

COFF / LOFF

COFF и LOFF –определяют позицию окна с областью проекции в файле сегмента изображения.

4.2.4 Header Type #3– Image Data Function

This record defines physical image parameters (albedo or radiometric temperature). The structure of the image data function record is defined as:

Title: Image Data Function		**Id: IMAGE_DATA_FUNCTION**	
IMAGE_DATA_FUNCTION	::=	RERECORD	
{ Header_Type		UNSIGNED BYTE (**3**)	-- fixed value
Header_Record_Length		UNSIGNED SHORT ()	-- fixed value
Data_Definition_Block		ARRAY (Data_Def_Block_Size) of CHARACTERSTRING	-- variable size and contents in accordance with the product processing algorithm

Note: Data_Def_Block_Size = Header_Record_Length - 3
}

In current version this record type is not in use.

4.2.5 Header Type #4 - Annotation

The annotation record will be used to identify more precisely the product/data type and sub-type of the LRIT/HRIT file. It is assembled to allow for quick and easy detection of the most relevant file contents criteria and route it to the respective postprocessing function.

It can be assumed that all operating system in use in the ground segment and 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. Beside being used for file storage purposes, this header will contain all criteria for the DISE encryption process in one header record. The user station can use the annotation to apply filter, sorting and processing criteria.

The structure of the annotation record is defined as:

Title:Annotation Record		**Id: ANNOTATION**	
ANNOTATION	::=	RECORD	
{ Header_Type		UNSIGNED BYTE (**4**)	-- fixed value
Header_Record_Length		UNSIGNED SHORT (**64**)	
Annotation_Text		RECORD	
{ XRITchannelID		CHARACTERSTRING SIZE (**1**)	
FieldSeparator		CHARACTERSTRING SIZE (**1**)	'-'
DisseminationID		CHARACTERSTRING SIZE (**3**)	value between '000' and 999
Field Separator		CHARACTERSTRING SIZE (**1**)	'-'
DisseminatingS/C		CHARACTERSTRING SIZE (**6**)	
FieldSeparator		CHARACTERSTRING SIZE (**1**)	'-'
ProductID1		CHARACTERSTRING SIZE (**12**)	see Table 3
FieldSeparator		CHARACTERSTRING SIZE (**1**)	'-'
ProductID2		CHARACTERSTRING SIZE (**9**)	see Table 3
FieldSeparator		CHARACTERSTRING SIZE (**1**)	'-'
ProductID3		CHARACTERSTRING SIZE (**9**)	see Table 3
FieldSeparator		CHARACTERSTRING SIZE (**1**)	'-'
ProductID4		CHARACTERSTRING SIZE (**12**)	see Table 3
FieldSeparator		CHARACTERSTRING SIZE (**1**)	'-'
Flags		CHARACTERSTRING SIZE (**2**)	
}			
}			

Explanations

Annotation_Text

The Annotation_Text record contains the following fields of character strings:

- LRIT/HRIT Channel ID
'L' for LRIT dissemination channel, 'H' for HRIT dissemination channel. For the first character of LRIT and HRIT file names appearing in the ground segment and on the reception/User Station side, this Channel ID is used.

Disseminating S/C ID

This field will contain the name of the disseminating satellite.

The following name will be used: 'GOMS1__".

– **Product ID – (4)**

Following Table defines the contents of these.

ProductID (1) **12 char.**	S **-**	ProductID (2) **9 char.**	S **-**	ProductID (3) **9 char.**	S **-**	ProductID (4) **12 char.**	**LRIT/ HRIT file type**
‘GOMS1_1’ or ‘GOMS1_4’	-	9 digit spectral channel name	-	6 digit file segment number	-	acquisition start time	#0
‘GOMS1_1’ or ‘GOMS1_4’	-		-	‘PRO’	-	acquisition start time	#128
‘GOMS1_1’ or ‘GOMS1_4’	-	9 digit spectral channel name	-	‘PRO’	-	acquisition start time	#128
‘GOMS1_1’ or ‘GOMS1_4’	-		-	‘EPI’	-	acquisition start time	#129

The defined characterstrings for the ProductIDs (1) – (4) will be left aligned. Any remaining space in the field will be filled with ASCII characters ‘_’ (‘5F’h).

The ProductIDs will separated from each other by the ASCII character ‘-‘ (‘2D’h).

ProductID (1) contains satellite name: ‘GOMS1_X_____’.

X – data spatial resolution:

1 – spatial resolution 1 km,

4 – spatial resolution 4 km.

ProductID (2) - spectral channel names in the form XX_X_YYYY where:

XX_X – 4 digits identifying the central wavelength;

YYYY – 4 digits identifying the orbital position.

ProductID (2) values are presented in the following Table:

Channel	Spectral band, μm	ProductID (2)
1	0,5 – 0,65	00_6_076E
2	0,65 – 0,8	00_7_076E
3	0,8 – 0,9	00_9_076E
4	3,5 – 4,0	03_8_076E
5	5,7 – 7,0	06_4_076E
6	7,5 – 8,5	08_0_076E
7	8,2 – 9,2	08_7_076E
8	9,2 – 10,2	09_7_076E
9	10,2 – 11,2	10_7_076E
10	11,2 – 12,5	11_9_076E

ProductID (3) contains:

image file (type #0) – 6 digit file segment number equal to Segm_Seq_No from header type #128

prologue file (type #128) – ‘PRO’ characters

epilogue file (type #129) – ‘EPI’ characters.

ProductID (4) contains acquisition start time in the form of YYYYMMDDhhmm where:

YYYY – year

MM – month

DD - day

hh – hour

mm – minute

– ***Flags***

The Flags field will consist of 2 ASCII characters.

The first character identifies whether the LRIT/HRIT data field contains compressed or uncompressed data:

'C' identifies compressed data

'_' identifies uncompressed data

The second character identifies whether the LRIT/HRIT data field contains encrypted or unencrypted data:

'E' identifies encrypted data

'_' identifies unencrypted data

- FieldSeparator

The FieldSeparator consists of the single ASCII character ‘-‘ (‘2D’h).

4.2.6 Header Type #128 - Segment Identification

The use of this header type is mandatory for all files of type #0.
The structure of the segment identification record is defined as:

Title:Segment Identification		**Id: SEGMENT_ID**	
SEGMENT_ID	::=	RERECORD	
{ Header_Type		UNSIGNED BYTE (**128**)	-- fixed value
Header_Record_Length		UNSIGNED SHORT (**13**)	-- fixed value
GP_SC_ID		ENUMERATED SHORT	
Spectral_Channel_ID		ENUMERATED BYTE	
Segm_Seq_No		UNSIGNED SHORT	-- segment sequence number
Planned_Start_Segm_Seq_No		UNSIGNED SHORT	
Planned_End_Segm_Seq_No		UNSIGNED SHORT	-- planned end segment sequence number
Data_Field_Representation		ENUMERATED BYTE {no specific formatting (0), JPEG interchange format (1), T.4 coded file format (2) Wavelet coded file format (3)}	-- defines the representation of the LRIT/HRIT data filed
}			

Explanations

GP_SC_ID – satellite ID. The value is set to 19001.

Spectral_Channel_ID

MSU-GS spectral channel ID. The values are varied from 1 to 10.

Segm_Seq_No – identifies the segment sequence number.

Segmentation is applicable to the type #0 files (image data).

For file type #0 (image data), Segm_Seq_No establishes a fixed relationship to the geographical location of the data contents. The precise location of the image segment can be derived from COFF/LOFF in the image navigation record #2.

Planned_Start_Segm_Seq_No

This parameter represents the planned number of the first image segment to be disseminated based on the knowledge at the start of the repeat cycle. The value of this parameter figure will be kept stable until the end of the repeat cycle’s dissemination independent of the actual segment numbers being disseminated.

Planned_End_Segm_Seq_No

This parameter represents the planned number of the last image segment to be disseminated based on the knowledge at the start of the repeat cycle. The value of this parameter figure will be kept stable until the end of the repeat cycle's dissemination independent of the actual segment numbers being disseminated.

Data_Field_Representation

In the case data compression is applied to the data field of file type #0, Compression_Flag in header type #1 will be used to identify the compression method.

If the Compression_Flag is set to a non-zero value Data_Field_Representation is used to define more precisely the compression algorithm applied to data field of the LRIT/HRIT file:

- No specific formatting (0),
- JPEG Interchange Format (1),
- Wavelet Interchange Format (3),

The JPEG interchange format is used as baseline to support lossy compression for imagery type of data with 2 or more bits per pixel. Further compression parameters are contained in the data field of the LRIT/HRIT file.

The Wavelet interchange format is used as baseline to support lossless compression for imagery type of data.

4.2.7 Header Type #129 - Image Segment Line Quality

Title: Image Segment Line Quality Record		**Id: LINE_QUALITY**	
LINE_QUALITY	::=	RERECORD	
{ Header_Type Header_Record_Length Line_Quality_Entries		UNSIGNED BYTE (**129**) UNSIGNED SHORT () ENUMERATED SHORT	--fixed value --variable value
ARRAY SIZE (1..NL) OF RECORD			-- NL as defined in header type #
{ Line_Number_in_Grid		INTEGER	
Line_Mean_Acquisition		TIME CDS SHORT	
Line_Validity		ENUMERATED BYTE {Not derived (0) Nominal (1), Based on missing data (2), Based on corrupted data (3), Based on replaced or interpolated data (4) },	
Line_Radiometric_Quality		ENUMERATED BYTE {Not derived (0) Nominal (1), Usable (2), Suspect (3), Do not use (4) },	
Line_Geometric_Quality }		ENUMERATED BYTE {Not derived (0) Nominal (1), Usable (2), Suspect (3), Do not use (4) },	
}			

Explanations:

Line_Quality_Entries

These records reflect the information received from MSU-GS Structural Decompression Complex after geolocation and radiometric processing.

- **LineNumberinGrid** represents the line number in the grid.
- **LineMeanAcquisitionTime** represents the mean acquisition time of the line.

– **LineValidity** qualifies the line validity.

– **LineRadiometricQuality** qualifies the line radiometric quality.

5 DATA FIELD STRUCTURE

5.1 Image data files

The data field of image data files consists of a sequence of pixels, without any gaps inbetween. The size of one pixel (in bits) is specified in the image structure record as well as the number of columns (denoted as NC in the following) and the number of lines (NL herein). The pixels appear with the MSB first. The total number of pixels is NC·NL, thus the total data field size is NC·NL times the pixel size. The pixels are sorted linewise, from left to right and from top to bottom. Accordingly, column numbers are counted from 1 to NC, and line numbers from 1 to NL. Consequently, the first pixel in the data field (the left uppermost one) has the coordinates (1,1) and the last pixel (the bottom right one) has the coordinates (NC, NL). Following Figure shows the structure of an LRIT/HRIT image.

The compression flag in the image structure record has no direct effect on the presentation of image data.

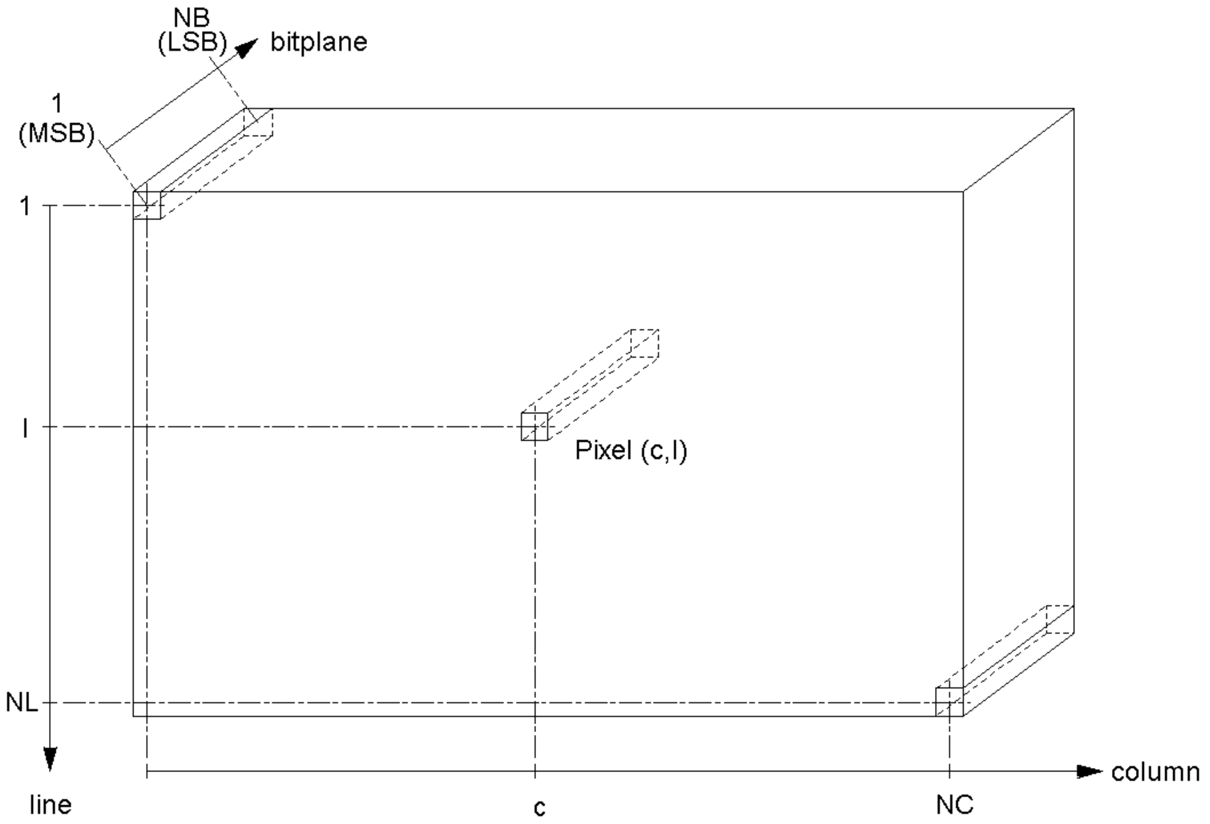


Fig. 3. LRIT/HRIT Image Structure

5.2 MSU-GS Level 1.5 data

MSU-GS Level 1.5 image size:

11136×11136 pixels in Visible band, spatial resolution 1 km in nadir;

2784×2784 in Visible and IR band, spatial resolution 4 km in nadir.

For segment size of 464 lines, the whole Earth disk image will contain 24 segment files with 11136 lines or 6 segment files with 2784 lines.

Line and column numbers are identified by header type #2 (image navigation).

All segments are numerated according to header type #128. Column offset is specified by header type #2. Segment numbers are assigned according to MSU-GS frame scanning.

5.3 File names

LRIT/HRIT file names are similar to the Annotation record in header type #4.

Here are some example LRIT/HRIT file names:

- Prologue for all channels:

H-000-GOMS1_-GOMS1_4_____-________-PRO______-200601261200-__;

- IR channel (5.7-7.0 μm), segment No 3, compressed, 4 km spatial resolution:

H-000- GOMS1_-GOMS1_4_____-06_4_076E -000003___-200601261200-C_ .

6 DATA LINK STRUCTURE

Data transfer is organized according to the document «LRIT/HRIT Global Specification», Issue 2.6, Date: 12.08.1999.

LRIT/HRIT files are used as input data. In order to ensure compatibility with Meteosat 8/9 station software the structure of the transport downlink is similar to the one described in «MSG Ground Segment LRIT/HRIT Mission Specific Implementation, Doc. No: EUM/MSG/SPE/057, Issue: 6, Date: 21 June 2006».

The data channel is organized according to the recommendations of the Consultative Committee for Space Data Systems (http://www.ccsds.org/). MSU-GS data is distributed in LRIT/HRIT format sequentially by channels, first bytes forward.

6.1 Overview of the transport layer

The variable length LRIT/HRIT files are used as the input data for the distribution. To ensure the continuity of the data transfer each LRIT/HRIT file is complimented with transport headers. The transport header consists of the file counter and LRIT/HRIT file size. The LRIT/HRIT file together with the transport header is called a **transport file**. The structure of the transport file is described in the table below:

Transport header		Data
File counter	Data field (in bits)	LRIT/HRIT file
16 bit	64 bit	1…(2^{64}-1) bit

Table 5. Transport file structure.

The data in the transport files is divided onto 8190-bytes blocks. The last block can be of any size in between 1…8190 bytes. At the end of each block there is a 2-byte CRC code.

6.2 Source packet

6.2.1 Source packet structure

The source CCSDS packet together with the user data contains some auxiliary information for storing, distribution and processing of data. The source packet structure is described below:

Source packet header (48 bits)	**Data field (variable length)**

Packet indication				Sequence control		Packet length	User data	
Version no	Type	Secondary Header Indicator	APID	Sequence Flags	Packet Sequence Count		Data	CRC
3 bits	1 bit	1 bit	11 bits	2 bits	14 bits	16 bits	vary	16 bits
2 bytes				2 bytes		2 bytes	Max 8190 bytes	2 bytes

Table 6. Source packet structure.

Source packet parameters:

- **Version No:**
  Set to ‘000’. Refers to ver.1 of CCSDS packet;
- **Type:**
  Set to ‘0’, not used;
- **Secondary Header Indicator:**
  Set to ‘0’. Secondary header is not used for LRIT/HRIT data;
- **APID:**
  Application process identifier. Set to 0 for LRIT/HRIT. This field defines data type for processing;
- **Sequence Flags:**
  ‘3’ if the packet contains unsegmented transport file;
  ‘1’ if the packet contains the first segment (first 8190 bytes) of transport file;
  ‘0’ if the packet contains a continuation segment of transport file;
  ‘2’ if the packet contains the last segment of transport file.
- **Packet Sequence Count:**
  Number of individual packet in the sequence. Cycled up to 16383.
- **Packet Length:**
  User data length -1;
- **User dete:**
  This field contains one block of the transport file;
- **CRC:**
  Cyclical redundancy check of user data. Calculated according to the formula
  $\mathbf{g(x) = x^{16} + x^{12} + x^{5} + 1.}$

6.2.2 Test packets

Test packets can be used in case no user data is provided or for test purposes.

Test packets are 8190 bytes with following headers:

Version No: ‘000’b
Type: ‘0’b
Secondary Header Indicator: ‘0’b
APID: ‘0x7FF’h
Sequence flag: ‘11’b (not segmented)
Packet length: 8190 bytes
User data: ‘0000000… 0’
CRC: ‘0x0000’h

6.3 Transport layer output data

Transport layer output data is a sequence of source packets with transport files’ data. Test packets are also allowed.

7 DATA TRANSFER STRUCTURE

The LRIT/ HRIT data transfer is organized according to the recommendations of the Consultative Committee for Space Data Systems (http://www.ccsds.org/). The data is transferred as a sequence of transport frames (CADU) and contains all information for decoding and processing.

7.1 Transport frame

The transport frame is a 1024-0byte structure suitable for data transfer and containing the transport frame data, header, Reed-Solomon coding symbols and sync marker. Transport frame structure is described below:

Sync marker	Transport frame header	Transport frame data	Reed-Solomon coding
4 bytes	6 bytes	886 bytes	128 bytes

Table 7. Transport frame structure.

7.1.1 Transport frame data

The Transport frame data is a 866-byte structure. It has 2-bytes pointer and 884-bytes of transport frame data. It is defined as M_PDU (multiplexing protocol data units). To form a Transport frame data the Transport layer output data is segmented onto 884-bytes blocks with pointers to first packet header in the block. The Transport Frame Data field is described below:

Header		Packet zone				
Not used.	First packet header pointer **(packet #k)**	End of packet #(k - 1)	Packet #k	Packet #(k + 1)	…	Begin of packet #m
5 bits	11 bits					
2 bytes		884 bytes				

Table 8. Transport frame data structure.

First 5 bits are not used. If there is no packet header in the packet zone the pointer is set to **'0x7FF'** HEX.

7.1.2 Transport frame header

VCDU – Virtual Channel Data Unit as defined by CCSDS contains header and transport frame data. The VCDU structure is shown here:

VCDU Header	VCDU data zone (поле данных транспортного уровня)
6 octets	886 octets

Table 10. VCDU structure

The decomposition of the VCDU header is given below:

Version number	**VCDU ID**		VCDU counter	Signalling field	
	Satellite ID	**Virtual channel ID**		**Replay flag**	Spare
2 bit	8 bit	6 bit	24 bit	1 bit	7 bit
6 octets					

Table. 9. Transport frame header structure

Mission specific use:

- **Version number:** set to '01'b;
- **Satellite ID:** to be assigned by CCSDS, now set to '0x00'h;
- **Virtual channel ID:** 0 for LRIT = 0, 1 for HRIT;
- **VCDU counter:** cyclic counter up to 16777216 for each virtual channel;

– **Signalling field:** replay flag is set to 0 for real time data, 1 for recorded data. Other bits are set to ‘0’.

7.1.3 Empty transport frame

Empty transport frames are used for test purposes or in order to maintain a continuous data flow at the specified packetized data rate to the physical layer. Those frames are defined as «**Fill VCDU**» by CCSDS. Header structure for empty transport frame is as follows:

– **Version number:** set to ‘01’b;
– **Satellite ID:** set to ‘0x00’h;
– **Virtual channel ID:** 63 (‘all-ones’);
– **VCDU counter:** current VCDU counter value;
– **Signalling field:** all ‘0’.

7.1.4 Reed-Solomon

The used Reed-Solomon code is (255, 223) with an interleaving of I = 4 to ensure error correction within transport frame. The VCDUs will be attached by 128 octets of Reed-Solomon check symbols to form a coded VCDU (C-VCDU).

7.1.5 Sync marker

An attached synchronisation marker (ASM) will have to precede the randomised C-VCDU to allow for frame synchronisation. The 32 bit pattern can be represented in hexadecimal notation as:

‘**1ACFFC1D**’h.

7.1.6 Randomization

Randomisation is applied to all LRIT/HRIT C-VCDUs. It is a process by which a pseudo-random sequence is bitwise exclusive-ORed to all 8160 bits of the C-VCDU to ensure sufficient data transitions.

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

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

The initial sequence state is all-ones.

The first 255 bits of the pseudo-random sequence from the generator are shown below:

1111 1111 0100 1000 0000 1110 1100 0000 1001 1010 0000 1101 0111
0000 1011 1100 1000 1110 0010 1100 1001 0011 1010 1101 1010 0111
1011 0111 0100 0110 1100 1110 0101 1010 1001 0111 0111 1101 1100
1100 0011 0010 1010 0010 1011 1111 0011 1110 0000 1010 0001 0000
1111 0001 1000 1000 1001 0100 1100 1101 1110 1010 1011 000…

8 PHISICAL DATA TRANSFER

Transport frames are used as an input data for physical data transfer via radiolink.

8.1 Convolutional coding

Convolutional coding is used for interference protection with following parameters:

- Redundancy R = ½;
- Code vector length К = 7;
- G1 = 1111001, G2 = 1011011,
  (no G2 path symbol inversion).
- G1 goes first.

8.2 Radiolink details

Main LRIT/HRIT radiolink details are described below:

Параметр	LRIT	HRIT
Central frequency	1691,0 MHz	1691,0 MHz
Bandwidth (BW)	0,660 MHz	1,960 MHz
Polarization	right-hand circular	
Baud rate	128 Kbit/sec	1 Mbit/sec
Radiolink baud rate	294 Kbit/sec	2,3 Mbit/sec
Modulation	PCM/NRZ/BPSK	PCM/NRZ/SQPSK
Electro-L effective isotropic radiated power (P*G)	22 dB*watt	22 dB*watt
Q-factor	≥ 4.5 dB/K	≥ 9.5 dB/K

Table 11. LRIT/HRIT radiolink details.