APPLICATION AND PRESENTATION LAYER SPECIFICATIONS FOR THE LRIT/LRPT/HRIT/HRPT DATA FORMAT

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1. INTRODUCTION

The satellite data direct broadcast service will migrate from the analogue Automatic Picture Transmission (APT) and Weather Facsimile (WEFAX) broadcast standard to digital equivalents now known as Low Rate Information Transmission (LRIT) and Low Rate Picture Transmission (LRPT) respectively. Commencement of the analogue to digital transition will be around the end of the decade. The transition implies that many WMO Members will have to replace much of their satellite ground segments (hardware and software) and revise their training.

The existing high resolution digital services will be continued with High Resolution Picture Transmission referred to as High Rate Picture Transmission (HRPT) and the geostationary equivalent will be High rate Information Transmission (HRIT).

The future LRIT/LRPT formats will follow the seven-layer ISO (International Organization for Standardization) OSI (open system interconnection) standard. It has been agreed to within CGMS that the satellite operators will define the Session, Transport, Network, Data Link and Physical layers. WMO agreed to provide guidance on the Application and Presentation layers. WMO recognised that the transition to the digital receiving system will greatly help its Members to create new capabilities from the digital data. In defining appropriate layers of the protocol, WMO is playing a prominent role in establishing for the new digital services.

Access to future digital data transmissions might be controlled by encryption by some satellite agencies.

2. SEVEN LAYER STRUCTURE FOR COMMUNICATION PROCESSES

There are seven layers specified for communication processes: Application layer, Presentation layer, Session layer, Transport layer, Network layer, Data link layer and Physical layer.

The top three layers (Application layer, Presentation layer and Session layer) refer to the content of the data. The bottom four layers (Transport layer, Network layer, Data link layer and Physical layer) refer to the transport mechanism.

The Application layer describes information interchange between application entities (between satellite operators and users). The user equipment should provide the ability to display information from the data provided by the presentation layer.

The Presentation layer describes data interchange between satellite operators and users. The user equipment should provide the ability to transform data from a form suitable for communication, to a form suitable for presentation. Users can access data with easily used formats for further processing or for display with Application layer functions.

The Session layer establishes links between satellite operators and users, without uncovering the transport mechanism. With the Session layer, satellite operators can control which user can receive and use the data. The method of control may be encryption at the satellite operator side. Since compression can be implemented with encryption, it can be put into the Session layer.

The Transport layer describes the form of the data to be transported, while the Presentation layer describes the content of the data to be transported. At the satellite operator side, a suitable packet channel is selected, the data file is portioned into one or more segments, each of them packed into a CCSDS (Consultative Committee on Space Data Systems) conforming source data packet. On the user side, the file segments are retrieved from the incoming package and the segments are reassembled into data files.

The Network layer controls the path on which the data is transported, so as to make more

efficient use of the telephone lines and to have a higher probability of connection. For satellite data broadcasting, the path is selected by the satellite operator.

The Data Link layer provides for correct logical transmission. The original concept in telecommunication for this layer is that when the physical transmission has errors, the Data Link layer provides for services such as retransmission, to ensure correct and in-order logical data received by the users. In case of direct data broadcast from the satellite, forward error correction methods are adopted to ensure logical and in-order transmission.

The Physical layer performs the transfer of the serial bit stream from the satellite operator to the users. At the user side, the modulated transmission carrier signal is demodulated to form the serial bit stream.

3. PRINCIPLES IN DEFINING APPLICATION AND PRESENTATION LAYER SPECIFICATIONS

In defining what kind of services will be provided to the users by LRIT/HRIT/LRPT/HRPT at the Application and Presentation layers, the following principles were adopted:

3.1 The Geostationary and polar orbiting services

* Geostationary services include satellite and numerical weather prediction products, meteorological reports, as well as broadcast data from the sensors, and administrative messages.
* Polar services only include direct broadcast data from the sensors and administrative messages.

3.2 Low rate and high rate

3.2.1 Channel selection:

* Low rate indicates a limited number of channels may be included in the data stream such as:

  IR window channel (11.0 μm)
  Visible channel (0.6 μm)
  Near infrared channel (0.8 μm)
  Water vapour channel (6.8 μm)
  Infrared channel (3.7 μm)
  Infrared split window channel (12.0 μm)

* High rate indicates all channels are included in the data stream.

3.2.2 Horizontal resolution:

* Low rate usually indicates full IR resolution (VIS at IR resolution)
* High rate usually indicates full horizontal resolution

3.2.3 Time frequency of images:

* Low rate means half hourly (geostationary) or all orbits (polar)
* High rate means all images (geostationary) or all orbits (polar)

3.2.4 Dynamic range:

* Low rate means 8 bit or higher
* High rate means full dynamic range

4. LRIT APPLICATION LAYER SPECIFICATIONS

4.1 Imager data display

* Navigation
* Calibration
* Remapping
* Enhancement
* Simple image processing (filtering, +, -, x, /, etc.)
* Zooming
* Single image or multiple image display
* Looping and zoomed looping

4.2 Sounder data display

* Plotting
* Contour
* Sounder image display
* Objective analysis to produce grid values.

4.3 Numerical products grid data display

* Plotting
* Contour

4.4 Meteorological observation display

* Plotting
* Thermodynamic display
* Cross-section
* Stability index calculation and display
* Objective analysis to produce grid values

4.5 Overlay display

* Image with sounding
* Image with grid data
* Image with meteorological observations

4.6 Administrative message display

* Message text display
* Message display in tables
* Message display in graphics

5. LRIT PRESENTATION LAYER SPECIFICATIONS

5.1 Images

5.1.1 Channel selection: 5 channels in the following priority order:

* Infrared window channel 11.0 μm
* Visible channel 0.6 μm
* Water Vapour channel 6.8 μm
* Infrared channel 3.7 μm
* Infrared Split window channel 12.0μm

5.1.2 Horizontal resolution:

* Full IR horizontal resolution

5.1.3 Image frequency:

* Half-hourly
* Plus at least 15 images every 3 hours from other polar and/or geostationary satellites

5.1.4 Dynamic range:

* 8 bits (256 grades)

5.2 Sounders

* Infrared sounder
* Microwave temperature sounder
* Microwave humidity sounder
* Ozone sounder
* GPS (Global Positioning System) sounder

5.3 Retransmission of other satellite data

* Low resolution imager or sounder data from other polar or geostationary meteorological satellites.

5.4 Products from meteorological satellites

* Tropical cyclone location, intensity and movement
* Volcanic ash detection
* Cloud type analysis
* Sea surface temperature

5.5 Numerical weather prediction products:

* Height
* Temperature
* Humidity
* Wind

5.6 Meteorological observations

* Surface weather (including ship) reports
* Upper air sounding (including ship) reports
* Aircraft reports
* Data collection platform reports

5.7 Satellite administrative messages

* Observation schedule
* Navigation information
* Calibration information
* Satellite performance information
* Space environment monitoring data

6. LRPT APPLICATION LAYER SPECIFICATIONS

6.1 Imager data display

* Navigation
* Calibration
* Remapping
* Enhancement
* Simple image processing (filtering, +, -, x, /, etc.)
* Zooming
* Single image or multiple image display
* Looping and zoomed looping

6.2 Sounder data display

* Plotting
* Contour
* Sounder image display
* Objective analysis to form grid values.

6.3 Administrative message display

* Message text display
* Message display in tables
* Message display in graphics

7. LRPT PRESENTATION LAYER SPECIFICATIONS

7.1 Imagers

7.1.1 Channel selection: 5 channels in the following priority order:

* Infrared window channel 11.0μm
* Visible channel 0.6 μm
* Near infrared channel 0.8 μm
* Infrared channel 3.7 μm
* Infrared split window channel 12.0μm

7.1.2 Horizontal resolution:

* Smoothly varying horizontal resolution image with 4 Km or better

7.1.3 Image frequency:

* 2 passes a day per satellite (i.e. 12-hourly intervals)

7.1.4 Dynamic range:

* 8 bits (256 grades)

7.2 Sounders

* Infrared sounder
* Microwave temperature sounder
* Microwave humidity sounder
* Ozone sounder
* GPS sounder

7.3 Other instrument data

* Local electric fields
* Space environment monitoring
* Data collection system
* Search & rescue

7.4 Satellite administrative messages

* Orbital parameters
* Telemetry
* Spacecraft ephemeris
* Attitude and timing data
* Other administrative messages

8. HRIT APPLICATION LAYER SPECIFICATIONS

8.1 Imager data display

* Navigation
* Calibration
* Remapping
* Enhancement
* Simple image processing (filtering, +, -, x, /, etc.)
* Zooming
* Single image or multiple image display
* Looping and zoomed looping

8.2 Sounder data display

* Plotting
* Contour
* Sounder image display
* Objective analysis to produce grid values.

8.3 Numerical weather products grid data display

* Plotting
* Contour

8.4 Meteorological observation display

* Plotting
* Thermodynamic display
* Cross-section
* Stability index calculation and display
* Objective analysis to form grid values

8.5 Overlay display

* Image with sounding
* Image with grid data
* Image with meteorological observation

8.6 Products

* Tropical cyclone location, intensity and movement
* Volcanic ash detection
* Cloud motion and water vapour winds
* Fog and low cloud detection
* Cloud type analysis
* Sea surface temperature and land surface temperature
* Outgoing long-wave radiation
* Solar irradiance
* Total ozone monitoring
* Upper troposphere humidity
* Precipitation estimation
* Temperature and moisture soundings

8.7 Administrative message display

* Message text display
* Message display in tables
* Message display in graphics

9. HRIT PRESENTATION LAYER SPECIFICATIONS

9.1 Images

* All channels
* Full horizontal resolution
* Full time frequency
* Full dynamical range

9.2 Sounders

All sounder data including
* Infrared sounder
* Microwave temperature sounder
* Microwave humidity sounder
* Ozone sounder
* GPS sounder
* Infrared atmospheric sounder interferometer
* Advanced scatterometer

9.3 Other Instrument data

* Space environment monitoring
* Data collection system
* Search & rescue

9.4 Satellite administrative messages

* Observation schedule
* Navigation information
* Calibration information
* Satellite performance information

10. HRPT APPLICATION LAYER SPECIFICATIONS

10.1 Imager data display

* Navigation
* Calibration
* Remapping
* Enhancement
* Simple image processing (filtering, +, -, x, /, etc.)
* Zooming
* Single image or multiple image display
* Looping and zoomed looping

10.2 Sounder data retrieval and display

* Sounder data retrieval
* Plotting
* Contour
* Sounder image display
* Objective analysis to form grid values.

10.3 Products

* Tropical cyclone location, intensity and movement
* Forest fire detection
* Volcanic ash detection
* Local sounding
* Fog and low cloud detection
* Cloud type analysis
* NDVI (Normalised Difference Vegetation Index)
* Sea surface temperature and Land surface temperature
* Outgoing long-wave radiation
* Total ozone monitoring

10.4. Administrative message display

* Message text display
* Message display in tables
* Message display in graphics

11. HRPT PRESENTATION LAYER SPECIFICATIONS

11.1 Images

* All channels
* Full horizontal resolution
* Full time frequency
* Full dynamic range

11.2 Sounders

All sounder data including

* Infrared sounder
* Microwave temperature sounder
* Microwave humidity sounder
* Ozone sounder
* GPS sounder
* Infrared atmospheric sounder interferometer
* Advanced scatterometer

11.3 Other instrument data

* Local electric fields
* Space environment monitoring
* Data collection system
* Search & rescue
* GPS position

11.4 Satellite administrative messages

* Orbital parameters
* Telemetry
* Spacecraft ephemeris
* Attitude and timing data
* Other administrative messages

12. SUMMARY

The following tables summarise application and presentation layer specifications for LRIT / LRPT / HRIT / HRPT format

ACRONYMS

APT	Automatic Picture Transmission
CBS	Commission for Basic Systems
CCSDS	Consultative Committee on Space Data Systems
CGMS	Coordination Group for Meteorological Satellites
GPS	Global Positioning System
HRIT	High Rate Information Transmission
HRPT	High Rate Picture Transmission
ISO OSI	International Organization for Standardization Open System Interconnections

LRIT	Low Rate Information Transmission
LRPT	Low Rate Picture Transmission
NDVI	Normalized Difference Vegetation Index
WEFAX	Weather Facsimile
WMO	World Meteorological Organization

Table: Application and Presentation Layer Specifications for LRIT / LRPT / HRIT / HRPT Format.

LOW RATE					
	Geostationary	**Polar**		**Geostationary**	**Polar**
Application Layer	LRIT Imager data display – Navigation - Calibration - Remapping - Enhancement - Simple image processing (filtering, +, -, x, /, etc.) - Zooming - Single image or multiple image display - Looping and zoomed looping Sounder data display - Plotting - Contour - Sounder image display - Objective analysis to form grid values Numerical products grid data display - Plotting - Contour Meteorological observation display - Plotting - Thermodynamic display - Cross-section - Stability index calculation and display - Objective analysis to produce grid values Overlap display - Image with sounding - Image with grid data - Image with meteorological observation Administrative message display - Message text display - Message display in tables - Message display in graphics	LRPT Imager data display - Navigation - Calibration - Remapping - Enhancement - Simple image processing (filtering, +, -, /, etc., - Zooming - Single image or multiple image display - Looping and zoomed looping Sounder data display - Plotting - Contour - Sounder image display - Objective analysis to form grid values Administrative message display - Message text display - Message display in tables - Message display	Presentation Layer	LRIT Imageries Channel selection: 5 channels in the following priority order: - Infrared window channel 11,0 μm - Visible channel 0.6 μm - Water Vapour channel 6.8 μm - Infrared channel 3.7 μm - Infrared Split window channel 12.0 μm Horizontal resolution: - Full IR horizontal resolution Image frequency: - Half-hourly plus at least 15 images every 3 hours from other polar and/or geostationary satellites Dynamic range: - 8 bits (256 grades) Sounders - Infrared sounder - Microwave temperature sounder - Microwave humidity sounder - Ozone sounder - GPS sounder Retransmission of other satellite data - Low resolution imager or sounder data from other polar or geostationary meteorological satellites Products from meteorological satellites - Topical cyclone location and intensity - Volcanic ash detection - Cloud type analysis - Sea surface temperature Numerical prediction products: - Height - Temperature - Humidity - Wind Meteorological observation - Surface weather (including ship) reports - Upper-air sounding (including ship) reports - Aircraft reports - Data collection platform reports Satellite administrative message - Observation schedule - Navigation information - Calibration information - Satellite performance information - Space environment monitoring data	LRPT Imageries Channel selection: 5 channels in the Following priority order: - Infrared window channel 11.0 μm - Visible channel 0.6 μm - Near infrared channel 0.8 μm - Infrared channel 3.7.μm - Infrared split window channel 12.0╞ μ Horizontal resolution: - Smoother horizontal resolution image with 4 Km or better Image frequency: - 2 paths a day per satellite (i.e. 12-hourly intervals) Dynamic range: - 8 bits (256 grades) Sounders - Infrared sounder - Microwave temperature sounder - Microwave humidity sounder - Ozone sounder - GPS sounder Other instrument data - Local electric fields - Space environment monitoring - Data collection system - Search & rescue Satellite administrative message - Orbital parameters - Telemetry - Spacecraft ephemeris - Attitude and timing data - Other administrative message

HIGH RATE					
	Geostationary	**Polar**		**Geostationary**	**Polar**
Application Layer	HRIT Imager data display - Navigation - Calibration - Remapping - Enhancement - Simple image processing (filtering, +, -, x, /, etc.) - Zooming - Single image or multiple image display - Looping and zoomed looping Sounder data display - Plotting - Contour - Sounder image display - Objective analysis to produce grid values. Numerical products grid data display - Plotting - Contour Meteorological observation display - Plotting - Thermodynamic display - Cross section - Stability index calculation and display - Objective analysis to form grid values Overlap display - Image with sounding - Image with grid data - Image with meteorological observation Products - Tropical cyclone location, intensity and movement - Volcanic ash detection - Cloud motion and water vapour winds - Fog and low cloud detection - Cloud type analysis - SST and LST - Outgoing long-wave radiation - Solar irradiance - Total ozone monitoring - Upper troposphere humidity - Precipitation estimation - Temperature and moisture soundings Administrative message display - Message text display - Message display in tables - Message display in graphics	HRPT Imager data display - Navigation - Calibration - Remapping - Enhancement - Simple image processing (filtering, +, -, x, /, etc.) - Zooming - Single image or multiple image display - Looping and zoomed looping Sounder data retrieval and display - Sounder data retrieval - Plotting - Contour - Sounder image display - Objective analysis to form grid values. Products development - Tropical cyclone location, intensity and movement - Forest fire detection - Volcanic ash detection - Local sounding - Fog and low cloud detection - Cloud type analysis - NDVI - SST and LST - Outgoing long-wave radiation - Total ozone monitoring Administrative message display - Message text display - Message display in tables - Message display in graphics	Presentation layer	HRIT Images - All channels - Full horizontal resolution - Full time frequency - Full dynamical range Sounders All sounder data including - Infrared sounder - Microwave temperature sounder - Microwave humidity sounder - Ozone sounder - GPS sounder - Infrared atmospheric sounder interferometer - Advanced scatterometer Other Instrument data - Space environment monitoring - Data collection system - Search & rescue Satellite administrative message - Observation schedule - Navigation information - Calibration information - Satellite performance information	HRPT Images - All channels - Full horizontal resolution - Full time frequency - Full dynamical range Sounders All sounder data including - Infrared sounder - Microwave temperature sounder - Microwave humidity sounder - Ozone sounder - GPS sounder - Infrared atmospheric sounder interferometer - Advanced scatterometer Other instrument data - Local electric fields - Space environment monitoring - Data collection system - Search & rescue - GPS position Satellite administrative message - Orbital parameters - Telemetry - Spacecraft ephemeris - Attitude and timing data - Other administrative message

Questions and Answers Regarding the Transition of Direct Broadcast of Meteorological Satellite Data from Analogue to Digital Mode

Q: What is a direct broadcast service?
A: A direct broadcast service is provided by some meteorological satellites that transmit satellite sensor data and products in real-time and near real-time for reception by ground stations within receiving range of the satellite.

Q: How many types of direct broadcast services are given at present?
A: Five types of data direct broadcast services are given at present. These are:

1. Direct broadcasts of low resolution data from polar orbiting meteorological satellites (APT/LRPT).

2. Direct broadcasts of low resolution data from geostationary meteorological satellites (WEFAX/LRIT).

3. Direct broadcasts of high resolution data from polar orbiting meteorological satellites (HRPT).

4. Direct broadcasts of high resolution data direct broadcast from geostationary meteorological satellites (HRIT).

5. Meteorological Data Distribution from Geostationary Meteorological Satellite (MDD).

Direct broadcast services from polar satellites (APT, LRPT, HRPT) only supply data from sensors, while direct broadcast services from geostationary satellites (WEFAX, LRIT, HRIT, MDD) supply additional products and meteorological data as well as data from the sensors.

Q: What is analogue data? What is digital data?
A: Satellite sensors produce signals of direct current with fluctuations. Analogue data transmissions disseminate signals which represent current strength directly to the ground receiving stations, while digital data transmissions firstly quantify the current strength into digits, then disseminate signals which represent digits to the ground stations. Digital transmission may avoid any possible errors during the transmission process. At present, low resolution data transmissions use analogue mode, high resolution data transmissions use digital mode.

Q: What is the advantage of digital transmissions compared to analogue transmissions?
A: The change of transmission mode from analogue to digital is a revolutionary step. With analogue transmission, users receive images which are only suitable for qualitative analysis of weather systems. With digital transmission, users receive digital measurements which after calibration provide quantitative measurements of radiation received by satellite sensors. With further processing, users may determine geophysical parameters describing the state of the atmosphere and the Earth's surface. Digital transmissions allow users to make a much wider application of satellite data, for example tropical cyclone intensity analysis, hazard monitoring and agricultural applications.

Q: Are these benefits attainable for developing countries?
A: Yes. Twenty years ago when high resolution digital data transmission commenced, the digital data receiving and processing systems were relatively complex, large in scale and expensive. Thus it was better for many developing countries to adopt the relatively simple, easy to maintain, and inexpensive analogue systems. These days, modern, inexpensive and highly interactive digital workstations are readily available, so it is now time to reap the benefits of digital technology.

Q: What preparation work is going on for the analogue to digital transition?

A: The preparation work is going on at the satellite operator side, the WMO secretariat side, and the equipment supplier side.

The satellite operators are coordinating their plans, time schedules and method of services through a body called Coordination Group for Meteorological Satellite (CGMS).

WMO's efforts are mainly in the following two aspects:

(1) Agreement and widespread promulgation of specifications of LRIT and LRPT and performance standards for digital receiving systems which use these services.

(2) Provision of advice to WMO members of the expected timetable of key events, and recommendations. The database of user stations maintained by WMO will greatly help in this task.

Suppliers of data receiving and processing systems will need to be well prepared before the transition commences.

Q: How has WMO assisted in defining specifications of LRIT/LRPT and performance standards for digital receiving systems?

A: WMO has defined the appropriate layers of the protocol for the future LRIT/LRPT formats. The future LRIT/LRPT formats will follow the seven-layer structure of ISO OSI (open system interconnections) standard. The two top layers (Application and Presentation layers) have been defined by WMO. This assists the satellite operators by confirming user requirements. WMO has also assisted suppliers of systems by defining the type of workstations they should supply.

Q: What is the advantage of following ISO OSI standards for LRIT/LRPT data format?

A: The ISO OSI standard isolates individual layers in open system interconnections and defines each layer by describing strictly what should be done in the layer. The advantage of isolating the communication process into layers is to break down a complex process into simpler steps. The individual steps may be implemented by different groups of organization which may be in different disciplines.

Q: What is the purpose of the Application and Presentations layers?

A: The Application and Presentation layers are the two highest layers of the seven-layer structure of ISO OSI standard. They refer to information and data exchange between satellite operators and users respectively.

The Application layer is concerned with the information exchange. It describes what type of functions a satellite workstation should have for appropriate utilisation of the data.

The Presentation layer is concerned with the data exchange. It determines what type of data should be transferred from the satellite operators to the users.

Q: What is the difference in the two layer specifications between high and low rate?

A: In direct digital data broadcasting, the advanced service is distinguished from the basic service by use of the term ”rate”. In the analogue service, the term “resolution” is used to distinguish between the advanced and basic services. The term “rate” refers to the amount of data broadcast in unit time. Data rates lower than 150 Kbs are classified as “low rate”, data rates higher than .5 Mbs are classified as “high rate”. With increased horizontal resolution, a larger number of channels, and more sensors, the overall data rates become higher. Thus the term “rate” expresses remote sensing capability more comprehensively than the term “resolution”.

Q: Is there a need for changes in equipment hardware and/or software to enable reception of new digital services?

A: Yes. New facilities or change of hardware/software will be necessary. The WMO is interacting with satellite operators through CGMS, to ensure that appropriate information is

issued as soon as possible.

Q: What are the benefits of having a high rate data utilisation work station?
A: Users can get both application data and data from more sensors. With more channels more accurate data and with better horizontal resolution a much wider range of applications can be undertaken.

Q: Where can I get further information?
A: Further information is contained in the WMO document “Application and Presentation Layer Specifications for LRIT/HRIT/LRPT/HRPT Data Format, SAT-19" which can be obtained from the WMO Secretariat. SAT-19 can also be downloaded from the WMO Internet Server at http://www.wmo.ch/hinsman/Publications.html. Further information is available at http://www.wmo.ch/hinsman/APT_WEFAXstatus.html.