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Prepared by USA
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USA S-Band Direct Readout Services Information

This paper provides a summary of the USA S-band direct readout broadcast services from its current and future polar-orbiting satellites. The USA discussed the data content and processing levels for the broadcast services and made available the projected equatorial crossing times for current and future polar-orbiting satellites. The USA plans to continue to support a global direct readout broadcast service in L-band frequencies with its next generation of National Polar-orbiting Operational Environmental Satellite System (NPOESS) spacecraft. The NPOESS Low Rate Data (LRD) service will be closely compatible with the broadcast parameters for the Advanced High Resolution Picture Transmission (AHRPT) format that have been accepted and approved by the Coordinating Group on Meteorological Satellites (CGMS). The NPOESS L-band service will be transmitted within the accepted 1698-1710 MHz frequency band using a bandwidth of 8.0 MHz. The data content from the NPOESS spacecraft will be mission specific to satisfy U.S. military and civilian user requirements, but will be comparable to and complement the data content of the L-band direct readout broadcast service that will be used on the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Metop spacecraft. The USA will continue to inform and coordinate with CGMS and the World Meteorological Organization (WMO) on the technical specifications for the L-band direct readout broadcast service on NPOESS.

USA S-Band Direct Readout Services Information

1.0 Introduction

The USA will continue to support a global S/L-band direct readout broadcast service on its current National Oceanic and Atmospheric Administration (NOAA) Polar-orbiting Operational Environmental Satellites (POES) and future National Polar-orbiting Operational Environmental Satellite System (NPOESS) spacecraft. NOAA will continue to operate the High Resolution Picture Transmission (HRPT) broadcast service on the remaining spacecraft (NOAA-N and NOAA-N') in its POES series of polar-orbiting satellites.

The NPOESS Integrated Program Office (IPO) and its Acquisition and Operations contractor, Northrop Grumman Space Technology (NGST) have carefully considered a recommendation from the Coordinating Group on Meteorological Satellites (CGMS) Task Force on Coordination of Data Formats and Frequency Planning for Polar-orbiting Satellites that was convened in January 2001. The Task Force noted that the USA (NOAA) would conform to the CGMS Global Specifications for Advanced High Resolution Picture Transmission (AHRPT) for the NPOESS spacecraft. As a result of this Task Force meeting, the IPO/NGST team has been developing a Low Rate Data (LRD) L-band direct readout broadcast service for NPOESS that will be closely compatible with but not identical to the broadcast parameters for AHRPT. To satisfy U.S. military and civilian user requirements for high resolution and large volume imagery data from the LRD direct broadcast service on NPOESS, certain modifications (described below) to the Global Specifications for AHRPT have been necessary to accommodate the higher data rates from instruments on NPOESS. The NPOESS L-band service will be transmitted within the accepted 1698-1710 MHz frequency band using a bandwidth of 8.0 MHz. The data content from the NPOESS spacecraft will be mission specific to satisfy U.S. military and civilian user requirements, but will be comparable to and complement the data content of the L-band direct readout broadcast service that will be used on the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Metop spacecraft. The USA will continue to inform and coordinate with CGMS and the World Meteorological Organization (WMO) on the technical specifications for the L-band direct readout broadcast service on NPOESS.

2.0 Polar-orbiting Operational Environmental Satellites (POES)

NOAA provides S-band HRPT direct readout broadcast service on its current primary operational POES spacecraft (NOAA-16 and NOAA-17). NOAA will continue to operate the HRPT broadcast service on the remaining spacecraft (NOAA-N and NOAA-N') in its POES series of polar-orbiting satellites. The High Resolution Picture Transmission system provides data from all POES spacecraft instruments at a rate of 665,400 bps. The S-band real-time transmission consists of the digitized, unprocessed output from five channels of the Advanced Very High Resolution Radiometer (AVHRR/3); the Television Infrared Observation Satellite (TIROS) Information Processor (TIP) data from the High Resolution Infrared Sounder (HIRS/3), the Solar Backscatter-Ultraviolet Spectral Radiometer (SBUV/2), the Space

Environment Monitor (SEM), and the Data Collection System (DCS/2); and data from the Advanced Microwave Sounding Unit (AMSU). All information that is necessary to calibrate the instruments' outputs is included within the real-time data stream. Detailed technical information on the POES HRPT data content can be accessed on-line and is contained in the NOAA KLM User's Guide available at: http://www2.ncdc.noaa.gov/docs/klm/index.htm.

3.0 National Polar-orbiting Operational Environmental Satellite System

Beginning in late 2009, the NPOESS Integrated Program Office, through its prime contractor, Northrop Grumman Space Technology, will launch NPOESS spacecraft into three orbital planes (1330, 1730, and 2130 equatorial ascending nodal crossing times) to provide global coverage with a data refresh rate of approximately four hours. NPOESS spacecraft will simultaneously broadcast two continuous real-time data streams, at High (X-band) and Low (L-band) rates, to suitably equipped field terminals worldwide. The data rates for these NPOESS direct readout broadcast services will be much higher than the current Automatic Picture Transmission (APT) or HRPT real-time systems on POES or the Low Rate Picture Transmission (LRPT) system that will be on the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Metop spacecraft. NPOESS spacecraft will not have a real-time direct broadcast service in the 137-138 MHz (LRPT) frequency band.

The NPOESS LRD L-band broadcast will be transmitted at a carrier frequency of 1706.0 MHz using the full bandwidth of 8.0 MHz at a nominal data rate of 3.88 Mbps, with full Consultative Committee for Space Data Systems (CCSDS) convolutional coding, Viterbi decoding, and Reed Solomon encoding/decoding into a tracking receive antenna aperture not to exceed 1.0 meter diameter. The data rate for the NPOESS LRD broadcast will be about seven times the current data rate for the POES HRPT service and about 10% to15% higher than the 3.5 Mbps data rate for the AHRPT service on EUMETSAT's Metop spacecraft. U.S. military and civilian user requirements for high resolution and large volume imagery data from at least three channels of the Visible/Infrared Imager Radiometer Suite (VIIRS), in addition to data from other NPOESS instruments, have dictated the higher data rate and commensurate 8.0 MHz bandwidth in the 1.7 GHz band for the NPOESS LRD broadcast. Some data compression (Lossy or Lossless) may be employed for the LRD link to accommodate the set of Environmental Data Records (EDRs) that users have specified for this direct broadcast service. As the design for the NPOESS LRD service matures, the data rate may have to be increased above the nominal 3.88 Mbps, even with improved compression techniques, to allow for the full set of LRD data products.

The NPOESS LRD broadcast parameters (frequency, bandwidth, data rate, and data content) were selected to satisfy U.S. requirements for low-rate, real-time direct broadcast, as well as be closely compatible with the CGMS Global Specifications for AHRPT. The principal differences between the CGMS Global Specifications for AHRPT and the NGST technical specifications for the NPOESS LRD service are listed below, following the section headers contained in CGMS Document Number: CGMS 04; Issue: 1.0; Dated: 5 October 1998:

Sec 2.1 Source Packet Structure (Secondary Header)

Epoch (time reference): CGMS - 1/1/2001 NPOESS - 1/1/1958

The NPOESS approach for the first source packet of a segmented message includes within the Secondary Header following, "...Time_of_Day", 8 bits for PSC_Type and 8 bits for Spare.

Sec 4 Data Link Layer

The NPOESS approach has, in place of a 16 bit IN_SDU (Insert Service Data Unit) the following:

32 bits (note: IN_SDU is allowed to be mission Specific)
08 bits Counter_Extension - aids in data accountability
14 bits Spare
10 bits AES_Key_Serial_Number - AES key in use

To keep the coded virtual channel data unit (CVCDU) structure a CCSDS constant length, 16 bits have been removed from the M_PDU_Packet_Zone to reduce the size from 882 octets to 880 octets (in other words... two octets added to IN_SDU and two octets removed from M_PDU_Packet_Zone maintaining a consistent octet count w/CGMS).

Sec 6.1.1 Convolutional Encoding

Code Rate:	CGMS - 3/4	NPOESS - 1/2
Symbol Inversion:	CGMS - no	NPOESS - yes on G2
Puncturing:	CGMS - yes	NPOESS - no
Puncturing Scheme:	CGMS - as defined	NPOESS - n/a

Sec 6.1.2 QPSK Modulation

The NPOESS approach is SQPSK not QPSK.

Sec 6.1.2.2 Modulation Waveform

Roll-off factor Alpha: CGMS - 0.6 NPOESS - 0.25

Nominal Bandwidth CGMS - 1698.75 - 1703.25 MHz
CGMS - 1704.75 - 1709.25 MHz

NPOESS - Carrier RF - 1706.0 MHz
Bandwidth - 8.0 MHz

The NPOESS LRD direct broadcast service will deliver a subset of the full NPOESS sensor data set and is intended for U.S. and worldwide users of field terminals (land and ship-based, fixed and mobile environmental data receivers operated by Department of Defense (DoD) users and surface receivers operated by other U.S. government agencies, worldwide weather services, and other international users). The NPOESS Interface Data Processing Segment

(IDPS) software for LRD field terminals will allow users of the LRD service to process NPOESS Raw Data Records (RDRs) into EDRs (level 2). The LRD field terminal on-line storage will also provide the capability to store and have available for retrieval, RDRs, Sensor Data Records (SDRs), Temperature Data Records (TDRs) and EDRs (level 0 to level 2) for the last 24 hours relative to the time when the EDR is produced.

The NPOESS LRD service will include data required to satisfy the U.S. user-specified, eight highest priority EDRs for real-time broadcast. The high priority EDRs listed below will be derived principally from data collected by four primary imaging/sounding instruments flying on the NPOESS spacecraft: the VIIRS; the Cross-track Infrared Sounder (CrIS) paired with the Advanced Technology Microwave Sounder (ATMS); and the Conical-scanning Microwave Imager/Sounder (CMIS).

1. Imagery (Visible, Infrared, Day/Night channels)
2. Atmospheric Vertical Temperature Profile
3. Atmospheric Vertical Moisture Profile
4. Global Sea Surface Winds (Speed and Direction)
5. Cloud Base Height
6. Cloud Cover/Layers
7. Pressure (Surface/Profile)
8. Sea Surface Temperature (SST)

Data for fifteen additional lower priority EDRs will also be included in the LRD broadcast. While the eight high priority EDRs will be produced at the LRD "objective" level of performance, including data latency of two minutes for imagery EDR processing and 15 minutes or less for the other EDRs, these lower priority EDRs will be produced between threshold and objective levels with less stringent latency requirements.

9. Aerosol Optical Thickness
10. Albedo
11. Cloud Effective Particle Size
12. Cloud Liquid Water
13. Cloud Optical Thickness
14. Cloud Top Height
15. Cloud Top Temperature
16. Land Surface Temperature
17. Ocean Wave Characteristics- Significant Wave Height
18. Precipitation Type/Rate
19. Precipitable Water
20. Snow Cover/Depth
21. Soil Moisture (Surface)
22. Suspended Matter
23. Total Water Content

Because LRD field terminal systems will not be required until 2007-2008 for testing the NPOESS LRD service, full details on the technical specifications for these field terminal systems, including functional specification of hardware and the associated interfaces will not

be available until mid-2005. As the NGST design for the LRD service matures, the USA will continue to inform and coordinate with CGMS and the WMO on the technical specifications for the L-band direct readout broadcast service on NPOESS.

4.0 Table for Polar-orbiting Satellite S-Band Direct Broadcast

Satellite	Equatorial Crossing Time and A/D Node	S-Band Direct Broadcast	Processing Level
NOAA-11	22:56 (A)	N/A	N/A
NOAA-12	04:43 (D)	HRPT	0
NOAA-14	19:00 (A)	HRPT	0
NOAA-15	06:48 (D)	HRPT	0
NOAA-16	14:03 (A)	HRPT	0
NOAA-17	10:15 (D)	HRPT	0
NOAA-N	14:00 (A)	HRPT	0
NOAA-N'	14:00 (A)	HRPT	0
NPOESS-1	09:30 (D)	LRD/AHRPT*	0, 1a, 1b, 2**
NPOESS-2	13:30 (A)	LRD/AHRPT*	0, 1a, 1b, 2**
NPOESS-3	05:30 (D)	LRD/AHRPT*	0, 1a, 1b, 2**
NPOESS-4	09:30 (D)	LRD/AHRPT*	0, 1a, 1b, 2**
NPOESS-5	13:30 (A)	LRD/AHRPT*	0, 1a, 1b, 2**
NPOESS-6	05:30 (D)	LRD/AHRPT*	0, 1a, 1b, 2**

*Note - Technical specifications for the Low Rate Data (L-band) direct broadcast service from NPOESS will be closely compatible with, but not identical to the AHRPT Global Specifications adopted by CGMS. See text for details.

**Note - NPOESS data from level 0 through level 2 (processed NPOESS Environmental Data Records [EDRs] or derived geophysical parameters) will be available and accessible on suitably equipped field terminals using NPOESS Interface Data Processing Segment (IDPS) software appropriate for the type of field terminal.