

METOP Direct Broadcast Satellite to Ground Interface details for HRPT users

Regional Advanced
Retransmission Service (RARS)

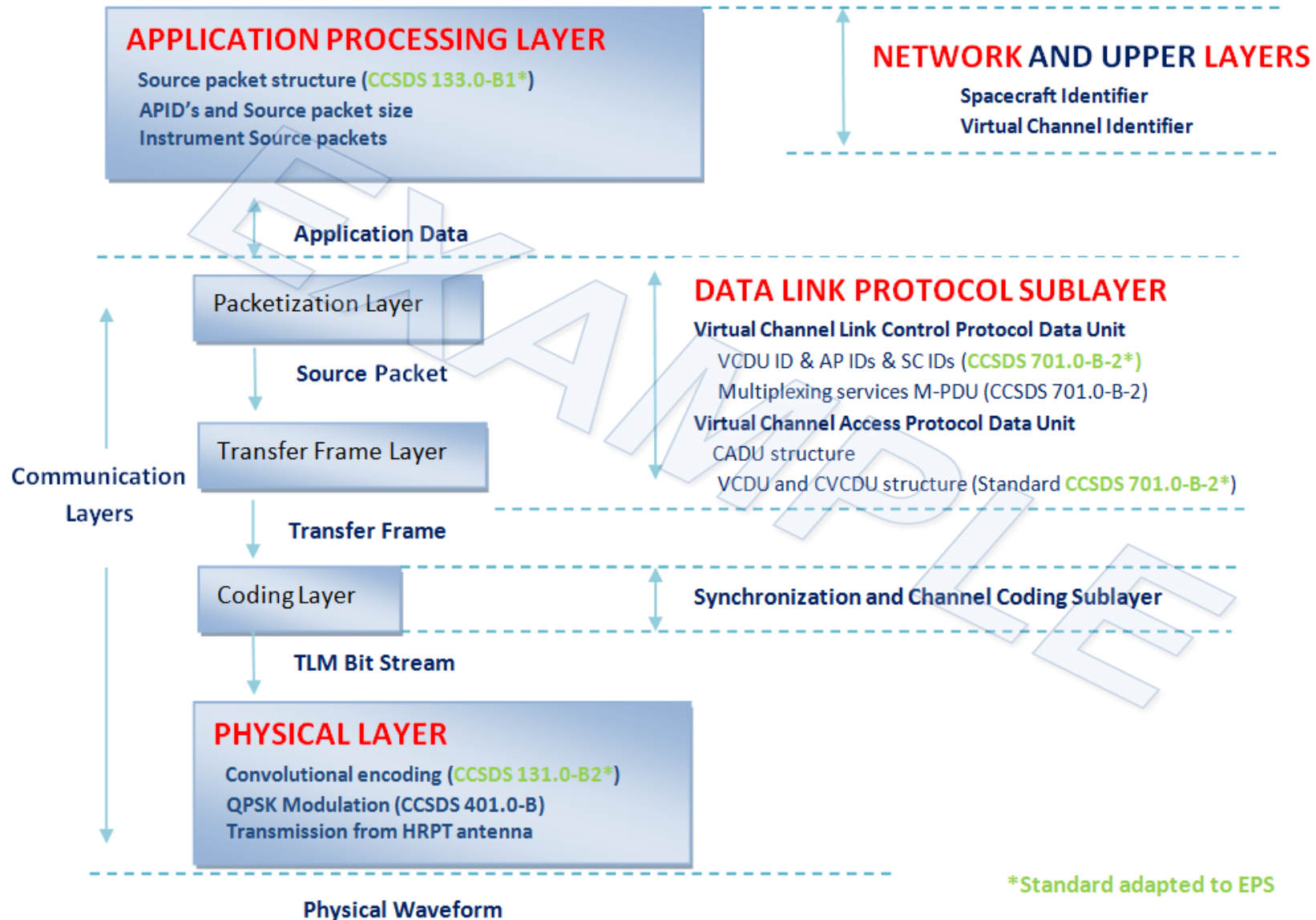
L band acquisition data



SPACECRAFT ORBITS DETAILS

- Lower polar orbit, **Sun-synchronous Orbit**
- Inclination: **98.7°** (eccentricity ~0)
- Altitude of **817 kilometers**
- Orbital period: **101min**
- Track Repeat Cycle: **29 Days / 412 Orbits**
- Local Time of Ascending Node: **21:30**
- MetOp-A International Designator: **2006-044A**
- MetOp-B International Designator: **2012-049A**
- MetOp-C International Designator: **TBA**

CCSDS Service Layer



APPLICATION LAYER I

- **SOURCE PACKET STRUCTURE** ,Standard **CCSDS 133.0-B-1***

PACKET PRIMARY HEADER (6 octets)						PACKET DATA FIELD (max: 65536 octets)				
Packet Identification 2 octets			Packet Sequence Control 2 octets		Packet length 2 octets	Secondary header 8 octets		User Data Variable		
Version Number 3 bits "000"	Type 1 bits "0"	Secondary Header Flag 1 bits "1"	APID 11 bits	Seq. flag 2 bits "11"	Packet Seq. Count 14 bits	UTC time stamp 64 bits UTC		Ancillary data Even nb. Of octets	Application data Even nb. Of octets	PEC 16 bits
16 bits			16 bits		16 bits	64 bits	SBT +8 bits	Variable	Variable	16 bits

Mission Details:

• Packet identifier:

- **Version number:** it is part of the Packet identifier
- **Type: 0** (This bit is not used within AOS)
- **Secondary Header Flag:** always set to **1** to indicate the presence of a secondary header.
- **API:** Application Process Identifiers are listed in the following slides.

APPLICATION LAYER I

Mission Details:

- **Packet Sequence Control:**
 - **Sequence Flag:** set to **11** to indicate that the packet contains un-segmented User Data (max. length 65542 octets)
 - **Packet Sequence counter** (for ASCAT instrument): is unique and the source packets is used for all ASCAT APID's.
- **Secondary Header:**
 - **UTC time stamp:** compliant to Standard **CCSDS 301.0-B-3** , “Level 1” Time Code.
- **User Data:**
 - **Ancillary Data field:** 6 octets of secondary time stamp SBT (Satellite Binary Time):
 - 1 octet filled with “0”
 - 3 octets of coarse time (second)
 - 2 octets of fine time (2-16 second). A number of the LSB's (depending of the source) up to a maximum of 8 may be set to “0”.

A counter rollover happens every 224 seconds (half a year). This is equivalent to a modification of the epoch. It is synchronized with the time stamp in the Packet secondary header.
 - **Application data field:** information provided by the source.
 - **Packet Error Control Field (PEC):** this field is optional: if required by the user it shall contain one of the following checksums:
 - a) Cyclic Redundancy Checksum (CRC) computed over all other octets that constitute the packet. The polynomial generator shall be:
$$G(x) = x^{16} + x^{12} + x^5 + 1$$
 Both encoder and decoder shall be initialized with all ones state for each packet.
 - b) Vertical Parity Checksum calculated by performing an exclusive-OR on all the other octet pairs that constitute the packet.

APPLICATION LAYER II (EUMETSAT INSTRUMENTS)

APPLICATION	APID	Packetised Data Rates [bps]	Packet Size [octet]	Ancillary data OBT/ Addit. Infor [octet]	Application Data Length [octet]	PEC [octet]	Rate [pkt/sec]	Comment
EUMETSAT INSTRUMENTS								
MHS	34	3924	1308	6 / 0	1286	2	3/8	1 packet
IASI Spectrum								Range 128...191
Pixel 1	130		<8960	6 / 300	<8638	2	30/8	1 packet at the time among:
Pixel 2	135		<8960	6 / 300	<8638	2	30/8	Spectrum Pixel 1
Pixel 3	140		<8960	6 / 300	<8638	2	30/8	Spectrum Pixel 2
Pixel 4	145		<8960	6 / 300	<8638	2	30/8	Spectrum Pixel 3
IASI Image	150	15000000 (average over 8s)	<6202	6 / 30	<6150	2	30/8	Spectrum Pixel 4
IASI Verif.	160		<59400 >5200	6 / 60	<59318 >5118	2	34/8	IMAGE
IASI Aux.	180		1024 (max)	6 / 120	<882	2	5/8	Spectrum Verification
							1/8	Auxiliary packet
ASCAT	192...255	60000 (max)	660 (nom)	6 / 126	512 (nom)	2	<11,36	Rang [192...255] XX:00 no defined, 01 processed echo data, 10 processed noise data, 11 raw data grd With Y: 0 no external calibration ZZZ: 000 antenna slot 0, 001 antenna slot 1, 010 antenna slot 2, 011 antenna slot 3, 100 antenna slot 4, 101 antenna slot 5 With Y: 1 external calibration ZZZ: 000 ANTLF, 001 ANTLM, 010 ANTLA, 011 ANTRF, 100 ANTRM, 101 ANTRA
GOME-2	384...447	400000 (max)	18738	6 / 956	17490	2	8/3	Range [384...447] 1 packet
GRAS Occultation/tracking	448...511	60000 (max)	TBD	6 / TBD	TBD	TBD	TBD	Range [448...511] 1 packet among
Satellite Pkt	1	4352	544	6 / 0	524	0	1	Navigation mode
GRAS Nav RT	2	80	160	6 / 0	140	0	1/16	Occultation mode
GRAS Nav Red	3	32	64	6 / 0	44	0	1/16	
Administration Message	6	2008	8032	6 / 0	8012	0	1/32	

APPLICATION LAYER III (NOAA INSTRUMENTS)

APPLICATION	APID	Packetised Data Rates [bps]	Packet Size [octet]	Ancillary data OBT/ Addit. Infor [octet]	Application Data Length [octet]	PEC [octet]	Rate [pkt/sec]	Comment
NOAA INSTRUMENTS								
AVHRR/3 HR	103,104	622368	12966	6 / 0	12944	2	6	1 packet at the time among Channel 3A data (day) & Channel 3B data (night)
AVHRR/3 LR	64....70	39900 (max)	Variable	6 / 0	variable	2	4/1.33333	4 packets at the time among Channel 1 or 2 data Channel 3A or 3B data Channel 4 or 5 data Calibration data
AMSU-A1	39	2102	2102	6 / 0	2080	2	1/8	1 packet
AMSU-A2	40	1142	1142	6 / 0	1120	2	1/8	1 packet
HIRS/4	38	2907.5	2326	6 / 0	2304	2	1/6.4	1 packet
SEM	37	165.5	662	6 / 0	640	2	1/32	1 packet
A-DCS	35	7462	7462	6 / 0	7440	2	1/8	1 packet

- Instruments Source Packet Description**

The instrument data follows the CCSDS recommendation together with the specific requirements listed in the tables below, the packet data field structure is specific to each instrument and detailed in a dedicated document.

NETWORK LAYER

- VCDU-ID is a 14 bit data structure, consisting of a spacecraft identifier (8 bits) and a Virtual channel identifier (6 bits).

Spacecraft ID:

METOP 1	0000 1011
METOP 2	0000 1100
METOP 3	0000 1101
METOP simulator	0000 1110

Instruments	Virtual Channel Identifier
Spacecraft Housekeeping	34
MHS	12
AMSU A1/2, SEM HIRS	3
DCS	27
AVHRR High rate	9
IASI	10
ASCAT	15
GOME	24
GRAS positioning and timing data	34
GRAS sounding data	29
Administration messages	34
Fill VC	63

DATA LINK LAYER I

- VCLC and VCA, Standard **CCSDS 701.0-B-2** User data receive a **Grade 2 Service**.

VCDU PRIMARY HEADER (6 octets)					VCDU Insert zone 2 octets	VCDU DATA UNIT ZONE			CVCDU Check symbols 128 octets
Version Number	VCDU Id		VCDU Counter 3 octets	Signalling Field 1 octet		M_PDU header 2 octets		M_PDU Packet zone 882 octets	
	S/C id 8 bits	Type 6 bits		Replay flag "0"	Spare "0000000"	M_PDU header Spare	M_PDU first Header pointer		

Mission Details:

• **_VCDU Primary Header:**

- **_Version Number: 01** (Virtual channels)
- **Signalling field set to "0"** (real time).

- **Insert zone:** Encryption flag and Key number are set to **00 (hex)**

• **VCDU Data unit zone 884 octets:**

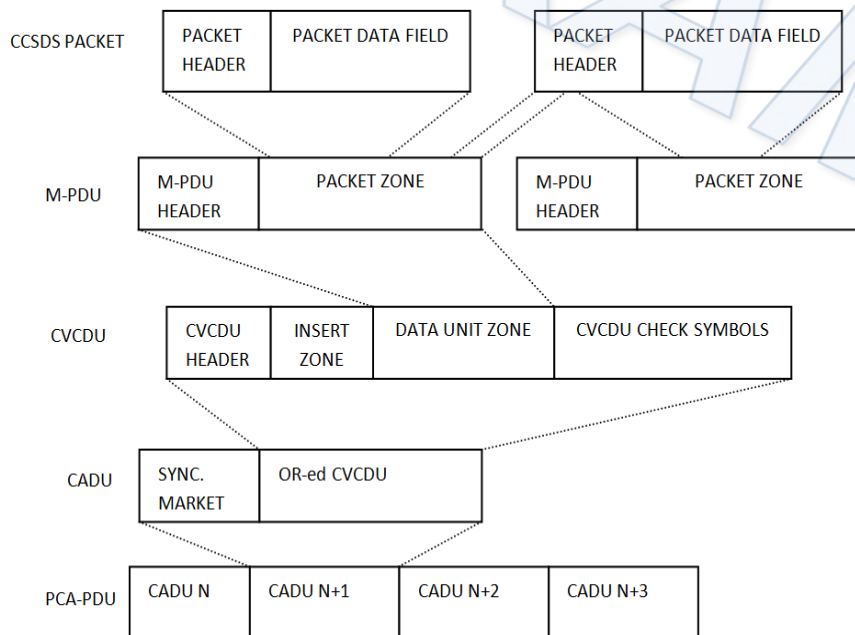
- a fill VCDU contains "all zeros"
- a fill VCDU is set to "all ones (63)" and the VCDU counter does not increment.

- **Check symbols 128 octets:** **Reed-Solomon (255,223)** calculated over the VCDU primary header and the VCDU Data Unit Zone, with and interleaving depth of I=4.

DATA LINK LAYER II

The protocol data unit of the Channel Access Procedures is the PCA_PDU, which is a serial stream of bits representing a continuous and contiguous stream of CADUs

CADU Structure is 1024 octets long (8192 bits) and consists in the CVCDU, OR-ed with a bit transition generator and prefixed by a 32-bit synchronization marker.



SYNCHRONISATION MARKET	CHANNEL ACCESS SLOT = OR-ed CVCDU
4 octets 1ACFFC1D hex	1020 octets
Probability VCA-SDU missing for the Grade 2 Service	
10 ⁻⁷	

PHYSICAL LAYER

- Convolutional encoding Standard **CCSDS 131.0-B-2**

Mission Details:

- Code rate: $\frac{3}{4}$ by puncturing the output of a $\frac{1}{2}$ rate encoder
- Phase relationship: **G1 is associated with the first symbol**
- The output of the Viterbi encoder has a rate of **4666.667 kbit/s** and is provided to the modulation section

- QPSK modulated + Pulse Shapping Standard CCSDS 401.0-B**

RF parameters:

The modulation is two synchronous NRZ filtered data streams, modulating the carrier on orthogonal axes. The streams are filtered in baseband by a network approximating the square-root raised cosine Nyquist filter:

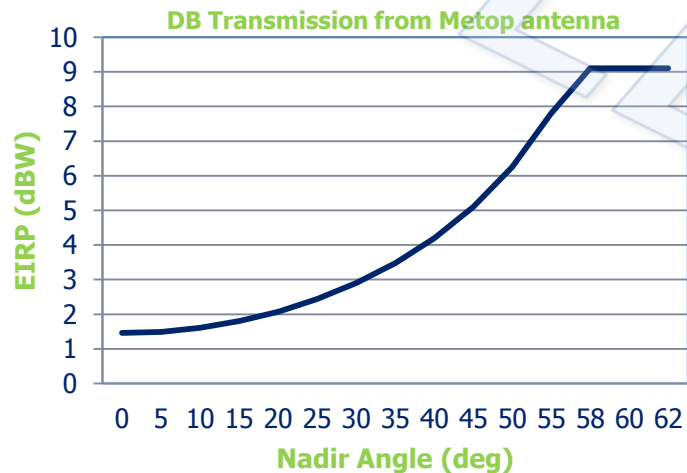
$$|H(j\omega)| = \begin{cases} \frac{\omega T_s}{2} \sin\left(\frac{\omega T_s}{2}\right) & 0 \leq \omega \leq \frac{\pi}{T_s}(1-\alpha) \\ \frac{\omega T_s/2}{\sin(\omega T_s/2)} \cos\left[\frac{T_s}{4\alpha}\left(\omega - \frac{\pi(1-\alpha)}{T_s}\right)\right] & \frac{\pi}{T_s}(1-\alpha) \leq \omega \leq \frac{\pi}{T_s}(1+\alpha) \\ 0 & \omega \leq \frac{\pi}{T_s}(1+\alpha) \end{cases}$$

The amplitude and group delay caused by the filtering network shall be within the masks shown in pulse-shaping table and max. group delay variation

Roll-off factor = 0.6
 $E_b/N_0 = 5$ dB
BER = 10^{-3}

	Frequency (MHz)	Bandwidth (MHz)
Nominal	1701.300	[1698.75-1703.25]
Back-up	1707.000	[1704.75-1709.25]

Note: nominal BW 99% of the total signal power Carrier freq. deviation $\pm 25.10^{-6}$



Pulse-shaping filter power mask:

Freq (kHz)	Rel. max power (dB)	Rel. min power (dB)
0	0.4	-0.4
0.466	0.4	-0.4
1.165	0.2	-5
1.398	-2	-9
1.631	-8	-17
2.33	-30	-
2.679	-30	-
3.495	-35	-

Maximum group delay variation

Freq Range (MHz)	Group delay (ns)
[0 - 1.17]	+/- 50
[1.17 - 1.755]	+/- 200