

TD 18 Metop Direct Readout AHRPT Technical Description

Doc.No. : EUM/OPS/TEN/08/1663
Issue : v3A e-signed
Date : 12 July 2021
WBS/DBS :

EUMETSAT
Eumetsat-Allee 1, D-64295 Darmstadt, Germany
Tel: +49 6151 807-7
Fax: +49 6151 807 555
<http://www.eumetsat.int>

Page left intentionally blank

Change Record

Version	Date	DCR* No. if applicable	Description of Changes
1	26/03/2009		Initial Issue
1J	28/03/2011		Updated to include AHRPT zone extensions
2	02/05/2013		Updated for Metop-B. Title changed AHRPT switch on/off updated
3	22/08/2019		Updated for Metop-C
3A	12/07/2021		Updates of signature table Remove the information related to Metop-A

***DCR = Document Change Request**

Table of Contents

1	INTRODUCTION.....	5
1.1	Applicable Documents.....	6
1.2	Reference Documents.....	6
1.3	Terminology	6
2	OVERVIEW	8
2.1	Service Characteristics.....	8
2.2	System Overview	8
3	AHRPT DATA STREAM	9
3.1	Data Structure.....	9
3.2	Data Content.....	11
3.3	Data Processing.....	11
4	RECEPTION STATION REQUIREMENTS.....	15
4.1	Recommendations on the Performance of an AHRPT User Station	15
4.1.1	RF Characteristics	16
4.1.2	Antenna.....	17
4.1.3	Low Noise Amplifier and Down Converter	17
4.2	Data Encryption.....	17
4.2.1	Station Key Unit.....	18
4.2.2	Key Updates.....	18
5	USER SUPPORT INFORMATION	20
5.1	User Notification Service	20
5.1.1	Multi-Mission Administrative Message User Guide.....	20
5.1.2	Two Line Elements.....	20
5.2	User Registration	20
5.3	User Service Helpdesk	21
APPENDIX A	AHRPT SKU FILES.....	22
A.1	Differences in the SKU files	22
A.2	User SKU files.....	22
A.2.1	XML example	22
A.2.2	User SKU file ASCII example	22
A.3	RUS SKU file XML example	23

Table of Figures

Figure 1: Metop AHRPT Reception	5
Figure 2: Channel Access Data Unit (CADU) Structure	10
Figure 3: Functional Diagram of an AHRPT User Station	15
Figure 4: The EUMETSAT SKU.....	18

Table of Tables

Table 1: Data disseminated via AHRPT	11
Table 2: IASI Instrument Source Packet re-ordering scheme.....	13
Table 3: Key characteristics of the L-Band AHRPT Metop B & C.....	16
Table 4: Recommended User Station antenna characteristics.....	17

1 INTRODUCTION

This document describes the Metop Direct Readout Service for users wishing to establish and operate User Stations to receive Metop AHRPT data.

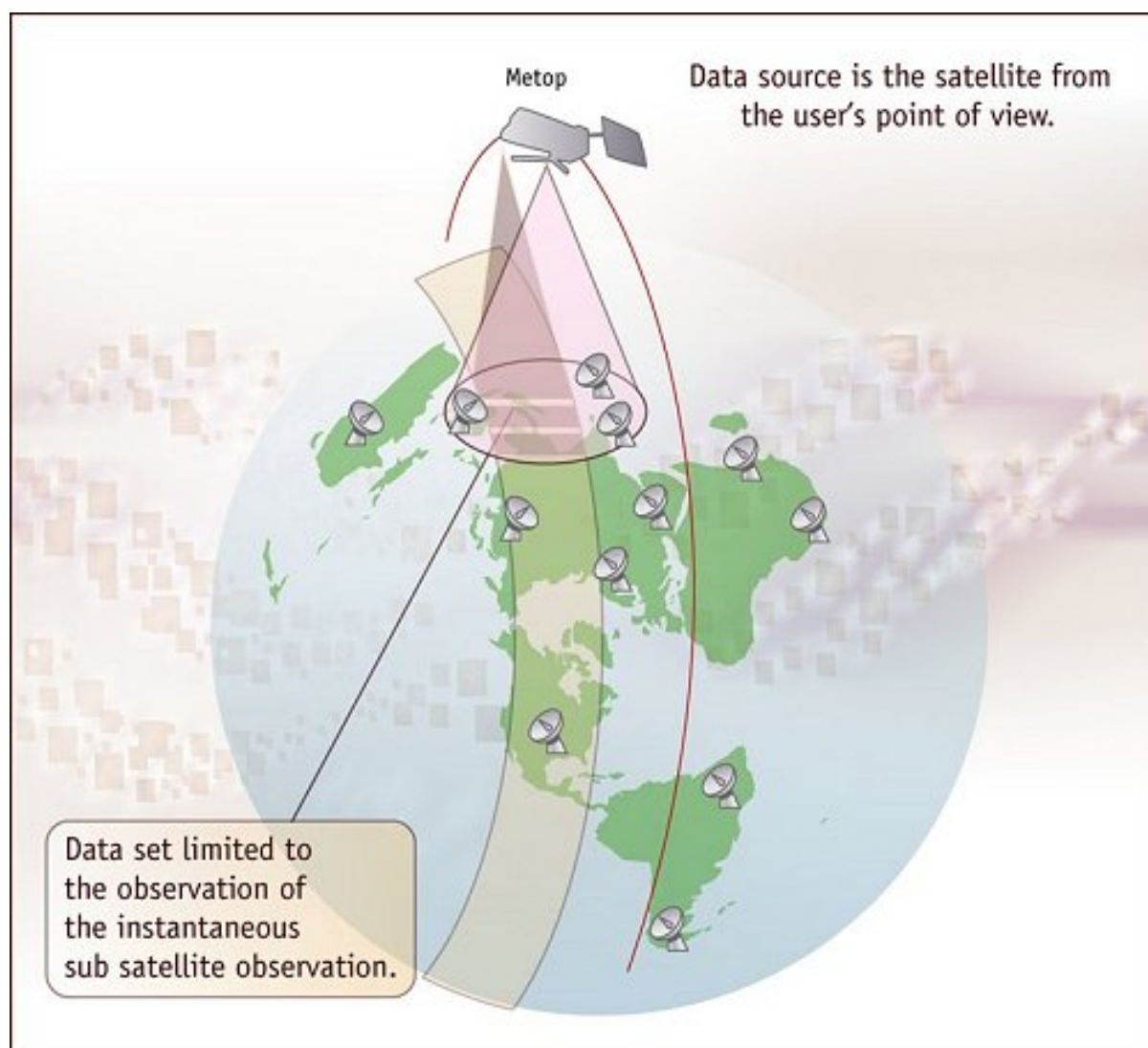


Figure 1: Metop AHRPT Reception

1.1 Applicable Documents

	Document Title	Reference
AD-1	Metop Space to Ground Interface Specification	MO-IF-MMT-SY-0001
AD-2	HRPT/LRPT Direct Broadcast Service Specification	EPS/SYS/SPE/95413
AD-3	EPS Data Denial Guide	EUM/OPS/USR/09/0579
AD-4	EPS Key Dissemination System - User Guide	EUM/TSD/MAN/04/0341
AD-5	GRAS Measurement Data Interface Control Document	MO.IC.SES.GR.0008
AD-6	IASI Measurement and Validation Data	IA-ID-1000-6477-AER
AD-7	GOME-2 Instrument Interface Control Document	MO.IC.MMT.GM.0001
AD-8	Multi-Mission Administrative Message User Guide	EUM/OPS/TEN/07/1573

1.2 Reference Documents

	Document Title	Reference
RD-1	Data Policy for Metop Data and Products	EUM/LAD/DOC/05/0350
RD-2	HRPT Reference User Station Technical Requirements Document	EUM/OPS/REQ/08/1903
RD-3	Meteosat Second Generation Interface Control Document Station Key Unit	EUM/MSG/ICD/114
RD-4	EUMETSAT Polar System (EPS) / Meteorological Operational satellite (Metop) Encryption System Specification	EPS.SYS.SPE.95424
RD-5	EPS - HRPT Direct Broadcast Services Specification	EPS.SYS.SPE.95413

Further information, as well as the above referenced documents, may also be obtained from the EUMETSAT User Service (see Chapter 5 “USER SUPPORT INFORMATION”) or directly from the EUMETSAT web site <http://www.eumetsat.int> .

1.3 Terminology

Acronyms and Abbreviations

Acronym/Abbr.	Explanation
A-DCS	Advanced Data Collection System
AHRPT	Advanced High Resolution Picture Transmission
AMSU	Advanced Microwave Sounding Unit
APID	Application Process Identifier
ASCAT	Advanced Scatterometer
AVHRR	Advanced Very High Resolution Radiometer for visible and infrared imagery, flown in polar orbit
CADU	Channel Access Data Unit
CCSDS	Consultative Committee for Space Data Systems
CVCUDU	Coded Virtual Channel Data Unit
DES	Data Encryption Standard
DES3	Triple DES encryption
EPS	EUMETSAT Polar System
EUMETSAT	European organisation for the exploitation of meteorological satellites
EUR	Euro

TD 18 Metop Direct Readout AHRPT Technical Description

FEP	Front End Processor
GOME	Global Ozone Monitoring Experiment
GRAS	GNSS Receiver for Atmospheric Sounding
HIRS	High Resolution Infrared Sounder
HKTM	House Keeping Telemetry
IASI	Infrared Atmospheric Sounding Interferometer
ICD	Interface Control Document
IIPS	Initial Joint Polar-Orbiting Operational Satellite System
KDS	Key Dissemination System
Mbps	Mega bits per second
MHS	Microwave Humidity Sounder
MHz	Megahertz
NOAA	National Oceanic and Atmospheric Administration (of the USA)
PBK	Public Key
PNK	Pseudo Noise Key
RF	Radio Frequency
RHCP	Right Hand Circular Polarisation
RUS	Reference User Station
SEM	Space Environment Monitor
SKU	Station Key Unit
TD	Technical Description
TLE	Two Line Elements
UG	User Guide
UTC	Universal Time Code
VCDU	Virtual Channel Data Unit
VCID	Virtual Channel Data Unit

2 OVERVIEW

2.1 Service Characteristics

The Metop Direct Readout Service provides to local user stations the real-time transmission of data limited to the instantaneous sub-satellite observation. The data source is the satellite as it passes over the user's field of view as illustrated in Figure 1. Readout of all instrument data can be achieved in the form of Advanced High Resolution Picture Transmission (AHRPT).

Data disseminated via AHRPT are:

- AVHRR/3 High Rate
- AMSU-A1
- AMSU-A2
- HIRS/4¹
- SEM
- A-DCS
- IASI
- MHS
- ASCAT
- GOME-2
- GRAS
- HKTM including Administration Message

¹HIRS is not available on Metop-C

2.2 System Overview

The current Direct Readout service comprises two satellites, Metop-B and Metop-C. AHRPT data are disseminated in L-Band, with a data rate of 3.5 Mbps. Local data coverage is of a radius of up to 1500 km centred at the sub satellite point. The AHRPT frequency of Metop-B and Metop-C is:

- 1) Prime 1701.3 MHz
- 2) Backup 1707.0 MHz

The nominal service is full global AHRPT readout for the Metop-B and Metop-C satellites. The EUMETSAT website contains the most up to date information on this subject (<https://www.eumetsat.int>).

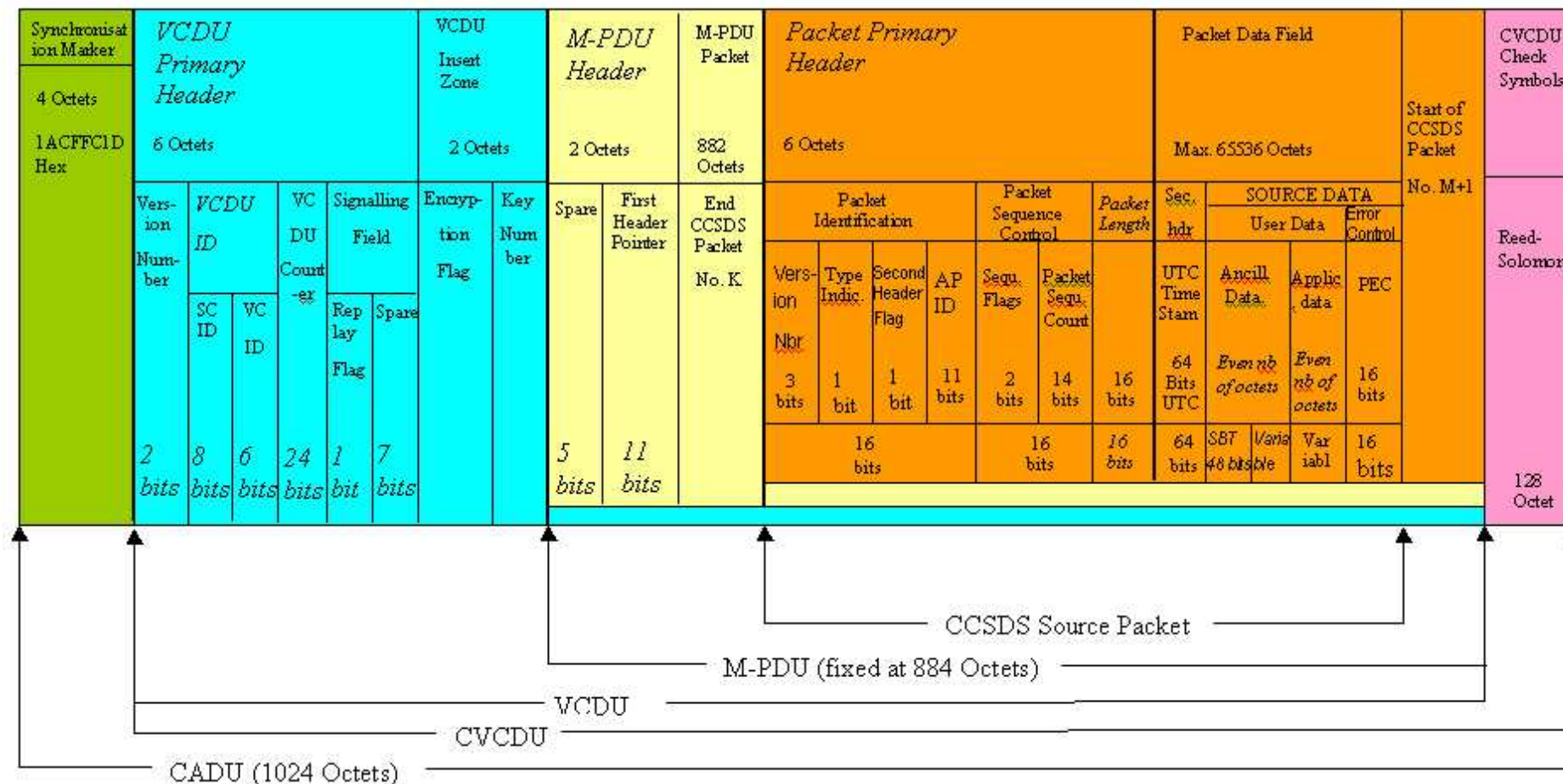
3 AHRPT DATA STREAM

This section provides an overview of the AHRPT data stream from the perspective of a user wishing to establish a User Station. The aim is to describe the basic characteristics of AHRPT such that users can determine the requirements of their user station and any software that might be required to manipulate the received data. Full details of AHRPT protocols and file formats are described in [[RD-5](#)].

3.1 Data Structure

Data are distributed as a stream containing Channel Access Data Units (CADUs), which require further processing to produce Metop L0 products. The stream holds multiplexed data from all Metop instruments, as well as spacecraft telemetry and administrative messages. In addition to being time ordered, frame synched and randomized, CADU's also hold Reed-Solomon decoding information and quality information.

A CADU packet can be processed further up to CVCDU, VCDU, M-PDU and Instrument Source Packets (ISPs) as CCSDS source packets; this is shown by the following diagram:

TD 18 Metop Direct Readout AHRPT Technical Description

Figure 2: Channel Access Data Unit (CADU) Structure

Further details (e.g.: PEC schemes, Reed-Solomon decoding description) can be found in [AD-2].

3.2 Data Content

This section describes the various data disseminated via AHRPT (see Table 1).

Instrument/Application	VCID	APID	Instrument/Application data rate (bps)
AVHRR/3 High Rate	9	103, 104	622368
AMSU-A1	3	39	2102
AMSU-A2	3	40	1142
HIRS/4	3	38	2907.5
SEM	3	37	165.5
A-DCS	27	35	7462
IASI	10	130, 135, 140, 145, 150, 160, 180	1578860
MHS	12	34	3924
ASCAT	15	192...255	41032
GOME-2	24	384...447	399744
GRAS Occultation data	29	448...511	60000
<u>Instruments' data sub-total:</u>			2719707
Satellite housekeeping packet	34	1	4352
Admin messages	34	6	2008
GRAS positioning and timing data	34	2, 3	80
<u>VCID 34 data sub-total:</u>			6440
All VCIDs (excluding overhead)			2726147
Protocol and RS-coding overhead (+16.1%) on all data:			438910
All VCIDs (including overhead)			3165057
Fill data			334943
Satellite complete data rate			3500000

Table 1: Data disseminated via AHRPT

3.3 Data Processing

The structure of the data received through a local station follows the Metop implementation of the CCSDS standard.

Note that the M-PDU packet is of fixed size (884 bytes) and can contain a variable number of CCSDS source packets or parts of CCSDS source packets (coloured orange in Figure 2 above) depending on the instrument.

Note as well the following deviations from the reference documentation required for the generation of L0 products, for some of the instruments:

GOME: CRC encoder/decoder should be initialised with “all zeros” (see [AD-7]).

- GRAS: extraction of its SBT must be performed according to the explanation given in the GRAS Measurement Data Interface Control Document [[AD-5](#)], not the one in [[AD-1](#)].
- IASI: measurement packets transmission sequence differs from the temporal sequence, and some packets have invalid time stamps (refer to Table 2 for a solution to this problem, and to [[AD-6](#)]).

The on-board time stamp available in the instruments' packets should not be used. Instead, it is recommended to use the OBT/UTC correlation parameters that are provided as part of the Admin message. See the EUMETSAT web site for details.

The EPS mission control centre maintains the on-board TMUTC source by uploading OBT-to-UTC correlation coefficients at regular intervals. Typically, the resulting accuracy of the TMUTC time stamp is in the order of ± 0.007 second relative to UTC. However, this typical performance is not guaranteed and reliance on this parameter is not recommended. In light of the above, it is recommended that users strictly use the OBT_ISP time stamp and perform the translation to UTC in their ground processing via the OBT-to-UTC correlation parameters. These parameters will be sent via the ADMIN message and published on the EUMETSAT web pages. The formula for computing UTC based on OBT_ISP and the correlation parameters are described in the Metop Space-to-ground Interface Specification [AD-1].

Likewise, the orbit information (state vectors) should be extracted from the Admin Message (APID 6) to perform the geo-location of the data.

Information on Level 1 and Level 2 processing of Metop instruments' data can be found in the product guides available on the EUMETSAT website (www.eumetsat.int).

4 RECEPTION STATION REQUIREMENTS

EUMETSAT has established a set of baseline recommendations for the “Direct Readout User” of Metop AHRPT data, these recommendations are set out in Section 4.1 “Recommendations on the Performance of an AHRPT User Station” and detailed as requirements in [RD-2].

4.1 Recommendations on the Performance of an AHRPT User Station

Baseline requirements:

- A tracking antenna. The satellite tracking function shall be able to track the Metop satellites throughout each satellite pass from the visible horizon (assume less than 5°) to 90° of elevation including zenith pass orbits and an azimuth range of at least 0° to 360.
- Receiver for Demodulation, bit synchronisation and Viterbi decoding.
- Front end processor (FEP) to demultiplex the CADU data and reconstruct the instrument source packets.

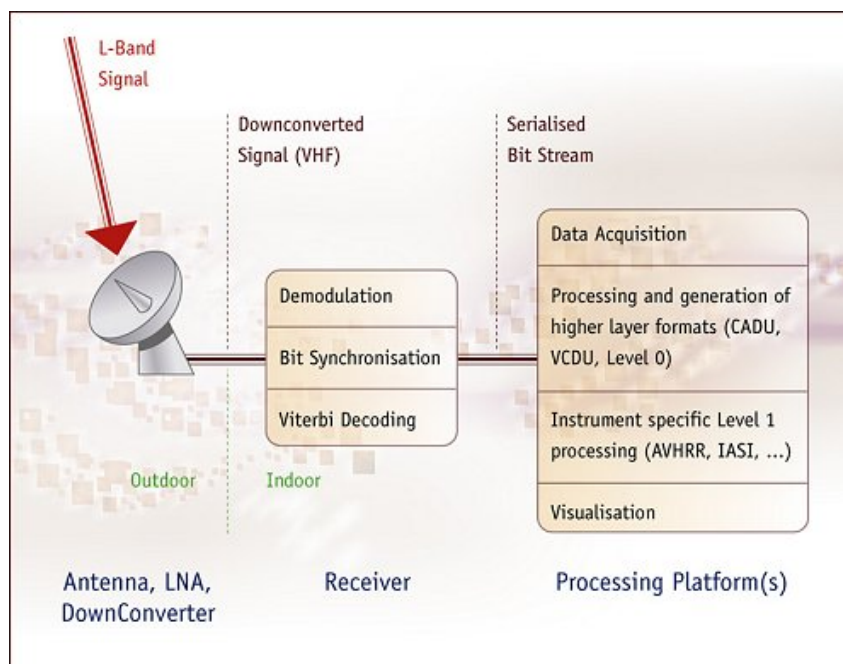


Figure 3: Functional Diagram of an AHRPT User Station

EUMETSAT maintains a list of known manufacturers of User Stations. This list is available from the EUMETSAT website, (see section 5.2 for the contact details).

4.1.1 RF Characteristics

Table 3 presents the characteristics of the radio frequency transmissions from the Metop satellites.

	AHRPT
Centre Frequency	1701.300 MHz or 1707.000 MHz
Bandwidth	4.5 MHz (99 % of the total signal power)
Polarisation	RHCP
Data rate	3.5 Mbps/4.666667 Mbps
Total coded data rate	2.3Mbps
Modulation	QPSK FEC 3/4
Satellite Axial Polarization	< 4.5 dB
Power Flux Density evolution during satellite Pass	154 dBW/m ² 4 kHz to -133 dBW/m ² 1.5 MHz
Carrier Frequency Deviation	$\leq \pm 25 \cdot 10^{-6}$

Table 3: Key characteristics of the L-Band AHRPT Metop B & C

4.1.2 Antenna

The following table presents the antenna characteristics to achieve the required figure of merit for a User Station as quoted in Table 4.

	AHRPT
Antenna Type	Parabolic tracking
Antenna Diameter	1.8 m
Azimuth Travel	450°
Elevation travel	−5° to 185°
Azimuth speed	< 20°/s
Elevation speed	< 8°/s
Tracking Accuracy	< 0,1°
G/T @ 5° elevation and clear sky	6 dB/K
Pointing loss	< 0.5 dB
Ground Station axial ratio	< 1 dB

Table 4: Recommended User Station antenna characteristics

The following may permit a reduction of the antenna size:

- Use of a better low noise amplifier reducing the system noise temperature;
- Use of an antenna system with higher efficiency;
- Fine resolution tracking system.

4.1.3 Low Noise Amplifier and Down Converter

The low noise amplifier should be mounted onto the antenna as near to the feed as possible. Normally the (first) down-converter will be integrated with the low noise amplifier. There are no particular recommendations for the choice of intermediate frequencies.

4.2 Data Encryption

Encryption mechanisms are used to control access to parts of the AHRPT data stream during periods of Data Denial, see [AD-3] and [RD-4]. A set of message keys that allow the activation of a Station Key Unit (SKU) are distributed to the registered user via the Key Dissemination System (KDS) refer to [AD-4]. Valid Public Keys are necessary for the operation of the SKU during periods of Metop data encryption.

Only AVHRR, AMSU, HIRS and SEM data will be subject to encryption during periods of Data Denial. Outside periods of Data Denial all data will be disseminated in the clear, see [RD-1].

4.2.1 Station Key Unit

A Station Key Unit (SKU) is a hardware device required to provide codes used in the decryption of the AHRPT data file during periods of Data Denial see [AD-3]. The SKU contains a microprocessor that is pre-programmed with a Master Key which, when combined with the other keys within the AHRPT allow decryption of the data. The keys that are used in the SKU for decryption purposes are so-called DES3 keys, which are composed by concatenation of 3 single DES keys. The keys are numbered Key (1), Key (2) and Key (3) from left to right.

The SKU interface provides a full duplex serial interconnection based on the TIA/EIA RS-422 standard.

For decryption to take place the user needs to load Public Keys into the SKU. The public keys are combined with the master key within the SKU to produce the Pseudo Noise key needed for the DES3 decryption process.



Front - View



Back - View

Figure 4: The EUMETSAT SKU

Files, which are transmitted in an encrypted form, are then decrypted using the Pseudo Noise Key obtained from the SKU. For each 100th CADU, the SKU has to calculate a dedicated Pseudo Noise Key (PNK).

An SKU is obtained either directly from EUMETSAT or via the station manufacturer where pre-integration is often performed. Full specification of the SKU is provided in [RD-3].

EUMETSAT is the sole supplier of SKUs and for each SKU there is a one-off, non-refundable charge of EUR 400. If preferred, the user can request that an SKU is supplied via their chosen manufacturer to allow for pre-integration into their user station. Registration of the User Station with EUMETSAT is mandatory if an SKU is required. .

4.2.2 Key Updates

The PUBLIC keys are updated periodically. When new keys are available the user will be informed automatically via email. The new keys will be placed on a EUMETSAT web server for

immediate download by the registered user. This service is password protected. The user name and password will be sent to the user upon registration. This service is known as KDS (Key Dissemination System) documented in [\[AD-4\]](#).

The same SKU will be able to handle the keys for Metop B &C.

5 USER SUPPORT INFORMATION

5.1 User Notification Service

The User Notification Service (UNS) provides up-to-date orbital information for the Metop and NOAA satellites which form part of the Initial Joint Polar-Orbiting Operational Satellite System (IJPS).

5.1.1 Multi-Mission Administrative Message User Guide

The Multi-Mission Administrative Message (MMAM) contains operational information relevant to users of the Metop HRPT direct broadcast service.

The MMAM is structured to contain administrative information for multiple satellites from multiple missions or programmes. An overview of the structure is provided on the right. A wide range of information is contained for the satellite transmitting the MMAM via its HRPT direct readout signal, including:

- Operational announcements
- Spacecraft and instrument status
- Navigation data, including orbital position, attitude and events
- Processing data, including OBT/UTC time correlation information

For further information on the MMAM either refer to [AD-8] or search for MMAM on the EUMETSAT web site www.eumetsat.int

5.1.2 Two Line Elements

In addition to the orbital information provided in the Admin Message, EUMETSAT makes available Two Line Elements (TLE) covering a period of roughly 3 days before and 3 days after a planned manoeuvre. The TLE information can be accessed from the UNS pages of the EUMETSAT Web site in either HTML or ASCII format.

5.2 User Registration

Users are requested to register their systems for three important reasons:

- Firstly, it informs EUMETSAT that Users are actively using the Direct Readout service;
- Secondly, it allows EUMETSAT to contact users to inform them on any service enhancements;
- Thirdly, and most important of all, it ensures that relevant points of contact (e.g. email address information) necessary for the delivery of decryption keys during periods of Data Denial are maintained.

Users can register their station via the registration portal: <https://eoportal.eumetsat.int/> to obtain up-to-date advice on user registration process, it is recommended that the prospective user first contact the EUMETSAT User Service Helpdesk.

5.3 User Service Helpdesk

The EUMETSAT Web pages, www.eumetsat.int, provide the latest information on the operational data, products and services provided by EUMETSAT. If you require any further information, please contact the EUMETSAT User Service Helpdesk:

Mail:

EUMETSAT User Service
Eumetsat-Allee 1
D - 64295 Darmstadt
Germany

Telephone: +49 (0) 6151 807 3660 / 3770

Fax: +49 (0) 6151 8073790

E-mail: ops@eumetsat.int

Web Site: <http://www.eumetsat.int>

Appendix A AHRPT SKU files

A.1 Differences in the SKU files

There are two different types of SKU files. Firstly, there are the files that are supplied, via KDS, to the user community; these files are described in the next section. Secondly, there are the files that are used by the reference User Station (RUS) at EUMETSAT HQ; this format is described later in this Appendix for the sake of completeness. *N.B.* The reference document [RD-2] refers to the RUS SKU file format and not the format supplied to the user community.

A.2 User SKU files

The SKU files supplied to users of the Metop direct readout service will be supplied the SKU files in the formats described in this section. The files are made available for download from KDS in one ZIP archive. There are two formats, one XML-marked-up and one plain-text file. Users should use the file format that is required by their User Station. The other file can be ignored.

A.2.1 XML example

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE DECRYPTION_FILE SYSTEM "DOWNLOAD.DTD">
<DECRIPTION_FILE ID="testuser3" DATE="20070227150423">
  <KEYSET CHANNEL="L" SKU="0007" DATE="27 Feb 2007">
    <KN ID="20">
      <PBK>47B6F0986C98379DF1D9212E2F2A7C47990F067914211233</PBK>
      <CRC>5265</CRC>
    </KN>
    <KN ID="21">
      <PBK>8CC081320A6624C7CF4FBAF7D4E50C5747B3894466B174DB</PBK>
      <CRC>00C3</CRC>
    </KN>
  </KEYSET>
  <KEYSET CHANNEL="H" SKU="0008" DATE="27 Feb 2007">
    <KN ID="20">
      <PBK>D029E67127702776BACD3174D20FABCF4CF69811B7DD0017</PBK>
      <CRC>21E3</CRC>
    </KN>
    <KN ID="21">
      <PBK>9242F2D7076EDC6E615C81D95FC446061AA7D631BC27E564</PBK>
      <CRC>AC5D</CRC>
    </KN>
  </KEYSET>
</DECRIPTION_FILE>
```

A.2.2 User SKU file ASCII example

Channel: LRPT	SKU: 0007	Date: 27 Feb 2007	
Key Number: 20	Public Key:		
47B6F0986C98379DF1D9212E2F2A7C47990F067914211233		CRC: 5265	
Key Number: 21	Public Key:		
8CC081320A6624C7CF4FBAF7D4E50C5747B3894466B174DB		CRC: 00C3	
Channel: HRPT	SKU: 0008	Date: 27 Feb 2007	
Key Number: 20	Public Key:		
D029E67127702776BACD3174D20FABCF4CF69811B7DD0017		CRC: 21E3	

Key Number: 21 Public Key:
9242F2D7076EDC6E615C81D95FC446061AA7D631BC27E564 CRC: AC5D

A.3 RUS SKU file XML example

The following XML extract is an example of the format of the SKU file format that is used only for the RUS at EUMETSAT HQ. This format is not made available to end users. It is included here only for completeness, and because some User Station manufacturers have been supplied with copies of the file format.

```
<?xml version='1.0'?>
<!DOCTYPE RUS_Encryption_Keys SYSTEM "RUS_Encryption_Keys.dtd">
<RUS_Encryption_Keys>
  <SKU ID="17">
    <KeyNumber ID="20">

<PublicKey>53CDB7EA3D4F002B53CDB7EA3D4F002B07815B0FAB4FF8B3</PublicKey>
      <CRC>98D3</CRC>
    </KeyNumber>
    <KeyNumber ID="21">

<PublicKey>AA098A5B44BFBAEAAA098A5B44BFBAEA01130BB7847F3588</PublicKey>
      <CRC>2ACB</CRC>
    </KeyNumber>
    <KeyNumber ID="26">

<PublicKey>07815B0FAB4FF8B307815B0FAB4FF8B353CDB7EA3D4F002B</PublicKey>
      <CRC>5D7C</CRC>
    </KeyNumber>
    <KeyNumber ID="28">

<PublicKey>07815B0FAB4FF8B307815B0FAB4FF8B31AC288653F11821C</PublicKey>
      <CRC>4603</CRC>
    </KeyNumber>
    <KeyNumber ID="29">

<PublicKey>01130BB7847F358801130BB7847F3588DF3F2B6EBF29196A</PublicKey>
      <CRC>F8AF</CRC>
    </KeyNumber>
    <KeyNumber ID="2E">

<PublicKey>07815B0FAB4FF8B307815B0FAB4FF8B307815B0FAB4FF8B3</PublicKey>
      <CRC>F7AD</CRC>
    </KeyNumber>
  </SKU>
</RUS_Encryption_Keys>
```