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Prepared by EUMETSAT
Agenda Item: 4.3
Discussed in WG I

Low Latency Data Access status report and Status of Implementation of Best Practices at EUMETSAT

Working Paper summary:

This paper presents status of operational direct broadcast systems and implementation of the CGMS Agency Best Practices at EUMETSAT in support to Local and Regional Processing of LEO Direct Broadcast data (CGMS/DOC/18/1008274) for each of the METOP and EPS-SG LEO satellite missions. This paper also introduces available direct broadcast information about the EPS Sterna constellation, for which approval of the programme is targeted in mid-2025. The EPS-Sterna information present in this document may evolve depending on the development of the programme.

Action/Recommendation proposed:

WG1 is invited to take note and comment on the status of implementation at EUMETSAT of the CGMS best practices in support to local and regional processing of LEO direct broadcast data.

1 INTRODUCTION

This paper presents status of operational direct broadcast systems and implementation of the CGMS Agency Best Practices at EUMETSAT of the CGMS Agency Best Practices in support to Local and Regional Processing of LEO Direct Broadcast data (CGMS/DOC/18/1008274) for each of the METOP and EPS-SG LEO satellite missions.

2 STATUS OF OPERATIONAL DIRECT BROADCAST SYSTEMS

The Status of Operational Direct Broadcast Systems at EUMETSAT is summarised in Table 1 below:

Instruments	METOP-B	METOP-C
AMSU-A	Operational	Operational
ASCAT	Operational	Operational
AVHRR	Operational	Operational
GOME	Operational	Operational
GRAS	Operational	Operational
HIRS	Non operational	N/A
IASI	Operational	Operational
MHS	Operational	Operational

Table 1: Status of Operational Direct Broadcast Systems at EUMETSAT

3 STATUS OF IMPLEMENTATION OF BEST PRACTICES

In the following sections, the status of implementation is given for METOP, EPS-SG and EPS-Sterna for each of the Best Practices (BP) defined in CGMS Agency Best Practices in support to Local and Regional Processing of LEO Direct Broadcast data (CGMS/DOC/18/1008274).

3.1 BP.01 Global Specification for Direct Broadcast

Best Practice BP.01: Operators should implement the agreed CGMS Direct Broadcast Services: LRPT/AHRPT Global Specification (Document No. CGMS 04).

Document No. CGMS 04 is available at: https://www.cgms-info.org/documents/Direct_Broadcast_Services__LRPT_AHRPT_Global_Specification,_Issue_2_01.pdf

3.1.1 METOP

Compliant. The METOP Direct Broadcast (AHRPT) is compliant with the CGMS Global Specification for Direct Broadcast, details available in METOP Space-to-Ground Interface Control Documents:

https://www-cdn.eumetsat.int/files/2020-04/pdf_mo_ds_esa_sy_0048_iss8.pdf

3.1.2 EPS-SG

Compliant. EPS-SG Direct Broadcast is compliant with the HRPT CGMS Global Specification for Direct Broadcast (X band at 7.825 GHz), details available in EPS-SG Space-to-Ground Interface Control Documents:

https://www-cdn.eumetsat.int/files/2020-06/pdf_dmt_1109989.pdf

3.1.3 EPS-Sterna

Compliant, direct broadcast to follow CCSDS standards in L-band.

3.2 BP.02 Timely provision of Space-to-Ground Interface Control Documents

Best Practice BP.02: CGMS operators should provide up-to-date and satellite-specific Space-to-Ground Interface Control Documents in English language at least 3 years before the launch of each satellite, including at least:

a) Frequency usage;
b) Polarization;
c) Encoding;
d) G/T requirements;
e) Data stream layout and content;
f) Conformance with CCSDS;
g) Conformance with the CGMS Global Specification (see section 1).

3.2.1 METOP

Compliant. The main documents describing the Space-to-Ground Interface are:
TD 18 METOP Direct Readout AHRPT Technical Description, https://www-cdn.eumetsat.int/files/2020-04/pdf_td18_metop_a_direct_read.pdf

and HRPT LRPT Direct Broadcast Services Specification, https://www-cdn.eumetsat.int/files/2020-04/pdf_mo_ds_esa_sy_0048_iss8.pdf

3.2.2 EPS-SG

Compliant. Space-to-Ground Interface details for the EPS-SG Direct Broadcast:
https://www-cdn.eumetsat.int/files/2020-06/pdf_dmt_1109989.pdf

3.2.3 EPS-Sterna

To be compliant, Space-to-Ground Interface Control Document to be provided.

3.3 BP.03 Provision of Current Orbit Information

Best Practice BP.03: CGMS operators should ensure timely provision of accurate and up-to-date orbit information based on their operational orbit determination and knowledge of satellite manoeuvres. The orbit information should be made available to Direct Broadcast reception station operators:

a) In TLE format via FTP or HTTP over the Internet;
b) Additionally, if required for the processing and geolocation of the sensor data, in the relevant mission specific format via FTP or HTTP over the Internet and/or via the satellite's Direct Broadcast signal;
c) Additionally, if the satellite operator chose to do so, in TLE format via the satellite's Direct Broadcast signal.

The satellite operator shall document:

d) The details of how and where the orbit information is made available;
e) For any mission specific format, the format definition and its application.

3.3.1 METOP

Compliant. The TLE for the METOP satellites are provided on this webpage: https://service.eumetsat.int/tle/ and includes links to the latest TLE for each individual satellite in plain text file format.

Additionally, the TLEs for all METOP satellites are included in the Multi-Mission Administrative Message transmitted via the METOP Direct Broadcast, see: https://www-cdn.eumetsat.int/files/2020-04/pdf_mmam_user_guide.pdf.

In both cases the TLE are derived from the EUMETSAT operational orbit determination and prediction and includes the effect of manoeuvres from shortly after the manoeuvres have been executed.

3.3.2 EPS-SG

Will be compliant, to be provided on the https://service.eumetsat.int/tle/ webpage prior to the launch of the first EPS-SG.

3.3.3 EPS-Sterna

Will be compliant, to be provided on the https://service.eumetsat.int/tle/ webpage prior to the launch of the first EPS-Sterna.

3.4 BP.04 Provision and maintenance of Product Processing software packages

Best Practice BP.04: Each LEO satellite operator should therefore ensure that:

a) Software packages for the relevant instruments are made available with a test version made available prior to launch and the operational version made available after end of commissioning of the satellite and as soon as feasible for the satellite operator;
b) To enable deployment of the software packages within organisations not permitting installation of pre-compiled software, source code should be made available;
c) Global and local product processing shall be harmonised in that brightness temperature products derived from both paths agree within tolerances that are not greater than few tenths (goal is 10%) of the respective performance requirements for bias error at a reference brightness temperature;
d) User support and maintenance services are available for the duration of the mission;
e) Notifications for software changes are provided to the user community;
f) Complete and comprehensive user documentation and S/W release documentation is supplied in English language;
g) The software installation procedure is designed to be easily executed by an untrained user;
h) The software package is executable on a standard computer platform, typically Linux/x86-64, providing a performance compatible with the timeliness requirements defined in the Guide to DBNet (CGMS-44-WMO-WP-10);
i) For reasons of performance, it should be possible to configure the software to process only the instruments and processing levels required locally;
j) Test data for verifying the installation of the S/W packages are made available.

3.4.1 METOP

Compliant.

The Product Processing software packages for the METOP Direct Broadcast are being provided and maintained by several EUMETSAT Satellite Application Facilities (SAFs):

- Numerical Weather Prediction Satellite Application Facility (NWP SAF, https://nwp-saf.eumetsat.int):
  - AAPP software for HIRS, AVHRR, AMSU, MHS and IASI;
- Ocean and Sea Ice SAF (OSI SAF, https://osi-saf.eumetsat.int):
  - Scatterometer Winds processing software for ASCAT;
- Radio Occultation Meteorology SAF (ROM SAF, https://rom-saf.eumetsat.int)
  - Radio Occultation Processing Packages (ROPP) for GRAS;
- Nowcasting SAF (NWC SAF, https://www.nwcsaf.org):
  - Cloud Mask and physical, optical and geometrical cloud properties for AVHRR.

a) EUMETSAT provides access to software packages and related documentation through the indicated SAF Web pages;
b) Source code is made available to users;
c) METOP brightness temperatures regional products are routinely monitored against global products to ensure differences are within acceptable thresholds. Monitoring details are available at: https://nwp-saf.eumetsat.int/site/monitoring/dbnet/;

d) User support and is a committed element of all SAFs. Access and support functions available after user registration for duration of the METOP missions;
e) User notifications are provided to users when new S/W versions are released;
f) S/W releases include extensive documentation in English, including validation results and algorithm descriptions;
g) The SAFs strive for a user friendly installation process (BP.04g), independently assessed in Operations Reviews with key users;
h) S/W releases are tested for a large set of standard computer platforms including Linux;
i) SAF S/W are configurable for sensor and area selection, resolution, auxiliary input data (e.g. NWP model output);
j) SAF operates reference platform in order to test local installations of S/W packages. The software provided by the OSI SAF, ROM SAF and NWC SAF uses level 1 data as its input. Additionally, EUMETSAT provides the Metopizer software providing Level-0 processing and other tools for manipulating CCSDS Instrument Source Packets and other related data types (CADU, t-VCDU packets, METOP L0 products) from the METOP Direct Broadcast. It can be found here: https://www.eumetsat.int/software.

3.4.2 EPS-SG

Will be compliant. The Product Processing software packages for the EPS-SG Direct Broadcast will be developed and distributed by several EUMETSAT Satellite Application Facilities (SAFs):

- Numerical Weather Prediction Satellite Application Facility (NWP SAF, https://nwp-saf.eumetsat.int):
  - AAPP software for MetImage, IASI-NG, MWS and ICI;
- Ocean and Sea Ice SAF (OSI SAF, https://osi-saf.eumetsat.int):
  - Scatterometer Winds processing software for SCA;
- Radio Occultation Meteorology SAF (https://rom-saf.eumetsat.int):
  - Radio Occultation Processing Packages (ROPP) for RO;
- Nowcasting SAF (NWC SAF, https://www.nwcsaf.org):
  - Cloud Mask and physical, optical and geometrical cloud properties for MetImage;
  - Ice Water Path for ICI.

The EPS-SG software packages will be made available in a similar way to the corresponding METOP software packages.

Additionally, EUMETSAT will be providing Metop-SGizer software, which will provide equivalent functionality to the Metopizer software, but for EPS-SG.

3.4.3 EPS-Sterna

In preparation.

3.5 BP.05 Provision of auxiliary data for instrument product processing

Best Practice BP.05: Each operator of instruments requiring auxiliary data for the product processing must make available the necessary auxiliary data on the Internet in a user-friendly and timely manner. Announcements of the availability of new auxiliary data should be issued giving the Direct Broadcast reception station operators sufficient time to update their systems.

3.5.1 METOP

Compliant. This data is provided by the EUMETSAT SAFs, see BP.04.

3.5.2 EPS-SG

Will be compliant. Scope and provision of auxiliary data for instrument product processing under consideration.

3.5.3 EPS-Sterna

In preparation. Scope and provision of auxiliary data for instrument product processing under consideration.

3.6 BP.06 Recommendations of channel selection for hyperspectral instruments

Best Practice BP.06: Each CGMS operator of hyperspectral instrument is responsible for defining a recommended channel selection scheme for global NWP purposes. The channel selection shall be made available to DB station operators prior to the launch of the first instrument and subsequently whenever the channel selection is modified.

3.6.1 METOP

Compliant. The channel selection for the IASI hyperspectral sounder is provided in the EUMETSAT Product Navigator (https://navigator.eumetsat.int/product/EO:EUM:DAT:METOP:EARS-IASI) under https://www-cdn.eumetsat.int/files/2020-04/pdf_iasi_red_prods_366-500.pdf

3.6.2 EPS-SG

Will be compliant, to be provided starting from the launch of the first EPS-SG.

3.6.3 EPS-Sterna

Non-applicable, no hyperspectral instruments on-board.

3.7 BP.07 Spacecraft and Instrument Operational Status

Best Practice BP.07: Each CGMS operator to publish and maintain up to date spacecraft and instrument operational status information on the Internet. The CGMS operators should establish a scheme to review on a regular basis that the published status information is up to date.

3.7.1 METOP

Compliant. The EUMETSAT user portal was recently migrated to the new webpage https://user.eumetsat.int/dashboard.

To access the Spacecraft and Instrument Operational Status in the tool, select the News & events panel that leads to the webpage https://user.eumetsat.int/news-events.

For example, METOP-B and METOP-C status:

Product Group Overview Service Name: GDS-Metop S/C Name: Metop-B	EUMETCast Europe
AMSU-A Level 1	
ASCAT Level 1	
ASCAT Soil Moisture	
AVHRR Level 1	
AVHRR Polar Winds	
GOME-2 Level 1	
GRAS Level 1	
HIRS Level 1	
IASI Level 1	
IASI Sounding Products	
MHS Level 1	
Multi-Sensor Products	

Product Group Overview Service Name: GDS-Metop S/C Name: Metop-C	EUMETCast Europe
AMSU-A Level 1	
ASCAT Level 1	
ASCAT Soil Moisture	
AVHRR Level 1	
AVHRR Polar Winds	
GOME-2 Level 1	
GRAS Level 1	
IASI Level 1	
IASI Sounding Products	
MHS Level 1	
Multi-Sensor Products	

Figure 1: METOP-B and METOP-C status as per EUMETSAT user webpage (access 04/03/2024)

3.7.2 EPS-SG

Will be compliant, to be provided starting from the launch of the first EPS-SG in the webpage https://user.eumetsat.int/news-events.

3.7.3 EPS-Sterna

Will be compliant, to be provided starting from the deployment of the EPS-Sterna constellation.

3.8 BP.08 Operational Announcements

Best Practice BP.08: Each CGMS operator to announce planned operations and status changes as well as any observed degradation of the spacecraft and its instruments via e-mail and optionally via other channels.

3.8.1 METOP

Compliant. The EUMETSAT User Notification Service (UNS) is accessible here: https://uns.eumetsat.int.

To access the Operational Announcements in the tool, select the Announcements tab and apply the relevant filtering.

To receive email notifications provided through the UNS, register via the Earth Observation Portal (EOP), https://eoportal.eumetsat.int/ . Once your account has been created, login to UNS (or follow the link from the EOP) to manage your email subscriptions via “My Subscriptions”.

3.8.2 EPS-SG

Will be compliant, to be provided starting from the launch of the first EPS-SG.

3.8.3 EPS-Sterna

Will be compliant, to be provided starting from the deployment of the EPS-Sterna constellation.

3.9 BP.09 Satellite Direct Broadcast and Reception Station Performance Requirements

Best Practice BP.09: When planning, designing, and developing satellite Direct Broadcast (DB) downlink capabilities, the CGMS agencies will strive to minimize, when possible, negative impacts on the DB community by communicating with manufacturers and users; coordinating with the other CGMS agencies; and considering these potential impacts during the CGMS agency’s decision-making process.

The performance of the satellite’s DB X-Band (7.8 GHz, ITU MetSat Band) downlink should be sufficient for nominal data reception at any reception station within the satellite’s footprint at elevations above 5 degrees and a G/T value of at least 21.20 dB/K. The calculation of the satellite DB performance shall include an allocation of at least 7.05 dB for reception station losses, rain and atmospheric losses, and link budget margin. The G/T is defined at the input of the IF receiver, at 5 degree antenna elevation and clear sky conditions.

A reception station operator may be required to establish a reception station with additional performance margin to account for local conditions, including climate, RF interference or the impact of an antenna radome.

3.9.1 METOP

N/A as METOP Direct Broadcast is in L-Band.

3.9.2 EPS-SG

Compliant. The Link Budget in Appendix A demonstrates nominal data reception when assuming a reception station G/T value of 21.2 dB/K and allocating 7.05 dB for reception station losses, rain and atmospheric losses and link budget margin.

3.9.3 EPS-Sterna

N/A as EPS-Sterna Direct Broadcast is in L-Band.

3.10 BP.10 Operators of satellites with DB should routinely monitor the quality of the DB downlink and address any anomalies in accordance with each organisation's established procedures, and notify users of degraded performance. Monitoring should include:

a) For each satellite, during the six months following DB signal activation, a validation that nominal reception is possible for a DB reception station anywhere within the footprint of the satellite DB antenna by acquiring all passes at an elevation of 5 degrees or more above the local horizon throughout a full satellite ground track repeat cycle. Nominal reception implies a positive link budget margin as well as the signal and data quality parameters defined under d) and e) below, being in their nominal range for a reception station corresponding to the minimum requirements of BP.09;
b) During at least one pass per day for each satellite, monitoring of the signal quality parameters and the data quality parameters, as defined under d) and e) below respectively, for the part of the pass which is at an elevation of 5 degrees or more above the local horizon;
c) During at least one pass per day for each satellite, monitoring of the data quality parameter degradation, attributable to frames or packets discarded or degraded on the spacecraft, prior to transmission to the ground;

where

d) Signal quality parameters should include receive signal strength, signal to noise ratio, spectral power distribution, and carrier, bit and frame lock statistics; and
e) Data quality parameters should include discarded frames and packets (failing error free decoding/reconstruction), missing frames and packets (calculated from measured frame and packet sequence counters), bad lengths (frame or packet out of tolerance length), and sequence errors (frame or packet detected

gaps/sequence error) per Virtual Channel Identifier (VCID) for frames and Application Process Identifier (APID) for packets.

3.10.1 METOP

Partially compliant.

a) N/A;
b) Partially compliant. Monitoring is performed manually in case of anomalies. Signal quality (BP.10.d) and data quality (BP.10.e) parameters are recorded for at least one pass per day;
c) Compliant. The METOP spacecraft is monitoring the data arriving and leaving the Multiplexer unit (FMU), the packets leaving the unit and the status of the unit (see Figure 2 for details). Telemetry information from the FMU is received at 1/16 Hz, once every 16 seconds. In case of issue with the data received, formatted or after output from to the LRPT/HRPT alarms are generated.

3.10.2 EPS-SG

Will be compliant, to be provided before the launch of the first EPS-SG.

3.10.3 EPS-Sterna

Under discussion, compliance to be assessed.

4 ACTIONS AND/OR RECOMMENDATIONS FOR CONSIDERATION BY CGMS WG-I

WG-I members are invited to take note and comment on the status of operational direct broadcast systems and implementation of the CGMS Best Practices at EUMETSAT in support to local and regional processing of LEO direct broadcast data.

APPENDIX A. Supporting information for BP.09

Supporting information for BP.09 *Satellite Direct Broadcast and Reception Station Performance Requirements*.

The Link Budget below assumes a reception station G/T value of 22.7 dB/K as defined in BP.09. The reception station losses (a), (c), (d), (e) rain and atmospheric losses (b), and link budget margin (f) add up to 11.41 dB, giving a positive margin of 4.36 dB relative to the 7.05 dB defined in BP.09 and sufficient for nominal data reception at any reception station within the satellite's footprint at elevations above 5 degrees.

Please note that the Link Budget is provisional and that the Space-to-Ground Interface details for the EPS-SG Direct Broadcast are not yet publicly released.

EPS-SG DB Link Budget			
Parameter	**Unit**	**Design Value**	**Source**
Frequency	GHz	7.825	EPS-SG Space to Ground ICD
Satellite EIRP	dBW	24.58	EPS-SG Space to Ground ICD
Propagation Path Length	Km	2890	Alt=850 Km, Elev Angle=5°
Free Space Loss	dB	179.54	
Polarisation Loss (a)	dB	0.07	EPS-SG Space to Ground ICD
Rain & Atmospheric Loss (b)	dB	2.8	EPS-SG Space to Ground ICD
Multipath Loss (c)	dB	0.2	EPS-SG Space to Ground ICD
Ground Antenna Pointing Loss (d)	dB	1	EPS-SG Space to Ground ICD
Ground Station G/T	dB/K	22.7	EPS-SG Space to Ground ICD
Power Flux Density at E/S	dBm/m^2	-85.63	
Boltzmann's Constant	dBm/Hz-K	-198.6	
Power Flux Density at E/S	dBW/m^2	-115.63	
DATA CHANNEL (QPSK)			
Data Power/No	dBm/Hz	87.72	
Information Rate	dB-Hz	79.16	188 Mbps with Reed Solomon (255/223) + Convolutional rate 1/2
Available Eb/No	dB	7.70	EPS-SG Space to Ground ICD
Required Eb/No for 10^{-6} FER	dB	3.06	EPS-SG Space to Ground ICD
Implementation Loss (e)	dB	3.18	EPS-SG Space to Ground ICD
Available Signal Margin (f)	dB	4.16	The reception station losses (a), (c), (d), (e) rain and atmospheric losses (b), and link budget margin (f) add up to

			11.41 dB, giving a positive margin of 4.36 dB relative to the 7.05 dB defined in BP.09 and sufficient for nominal data reception at any reception station within the satellite's footprint at elevations above 5 degrees.

Table 2: EPS-SG DB Link Budget

APPENDIX B. Supporting information for BP.10

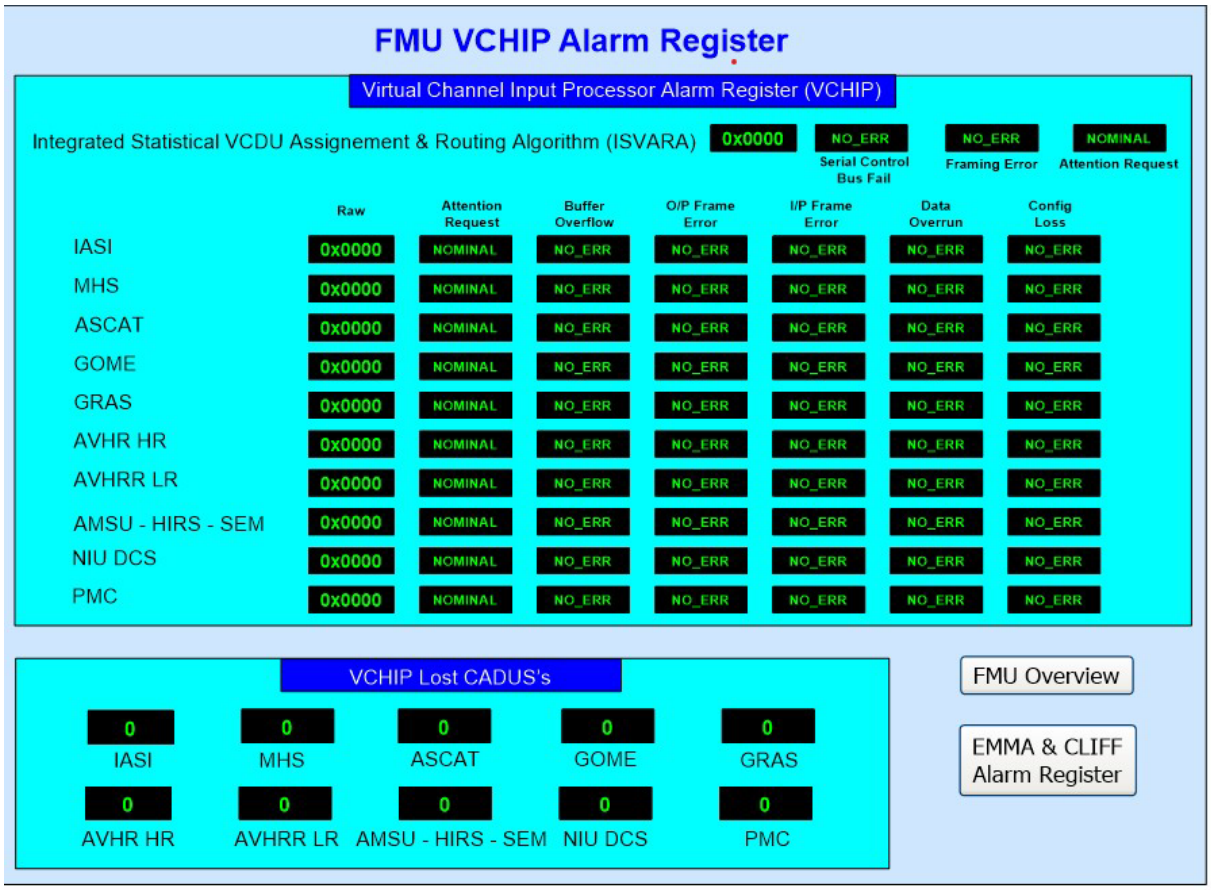

Figure 2: METOP permanent monitoring of all of the data arriving and leaving the Multiplexer unit (FMU)