1 INTRODUCTION

This document describes the content of EPS-SG RO Test Data version 2.1.

This version includes the products generated by processing also Beidou occultations, in addition to the data provided with TDP V2 and TDP V1. The RO L1B test data available in this package is created using the EUMETSAT In-house Prototype Processor.

The delivery contains RO L1b products, in netCDF, formatted according to

- EPS-SG RO Level 1b Product Format Specification V4B

As specified in the EPS-SG RO Level 1B Product Format Specification document, each Level 1B product file refers to an individual occultation and contains not only the associated bending angle profiles, but also the low level data needed to produce them. Such low level data (level 1a) includes, among the other variables, dual frequency signal phases, excess-phases, SNRs and pseudoranges time series, as well as LEO and GNSS orbits arcs and clock biases. Orbits are provided in the centre of mass for both satellites and for the transmitter and receiver antennas phase centre in the inertial reference frame.

2 METOP-SG ORBIT AND ATTITUDE DEFINITION

2.1 Leo Orbit:

In order to generate LEO orbits, as a first step, real data from the zenith antenna of the GRAS instrument on-board Metop-A was used, in combination with the final orbits and clocks from CODE analysis centre and other auxiliary data (earth orientation parameters, etc.) to compute a precise orbit of the Metop-A satellite. The usual POD setup is used for the centre of mass, antenna phase centre, etc. Therefore, the LEO orbit and clock bias provided will correspond to the real Metop-A satellite. Using IERS 2003 models (differences to new models, e.g., 2010, are negligible for this test data set), the position, velocity and clock bias for the LEO and the GPS constellation are produced at a 30s rate in both earth fixed and inertial reference frame in SP3-d format.

Occultations are available[1] in the standard EPSSG test scenario which is the following:

Orbit time interval (UTC, Format: YYYYMMDDHHMMSS)	**Comment**	**Scenario**
20070912084303 to 20070912102203	First orbit	Consecutive summer orbits
20070912102203 to 20070912120403	Second orbit	
20080223084603 to 20080223102803	Third orbit	winter orbit

Table 1: Coverage of the three orbits

2.2 Galileo, GLONASS and Beidou:

The nominal constellation is simulated for Galileo (GAL), GLONASS (GLO) and Beidou (BEI) with the following orbital parameters:

- GAL Walker 27/3/1 a=29600km i = 56.0 deg
- GLO Walker 24/3/1 a=25518km i= 64.8 deg
- BEI Walker 24/3/1 a=27878km i= 55.0 deg

[1] Occultation data are available just before the start of the orbit and just after the end of the orbit. This is a feature of the IDS, which is not cutting data in the borders if occultation data are available.

where *a* is the semi-major axis and *i* the inclination (eccentricity is set to 0).

Note that the constellations are equally distributed in Right Ascension of Ascending Node (RAAN): GAL planes are set to 0,120 and 240, BEI to 40,160,280 and GLO to 80,200,320 deg.

These initial conditions are propagated only taking into account the gravity in order to keep the Keplerian elements constant for the complete period.

GAL clocks are modelled with an initial offset and a drift with values comparable to the GPS constellation (See below some examples), whereas GLO and BEI clocks are set to zero for all epochs.

Finally, similar to GPS, the positions, velocities and clock offsets are provided together in earth fix and inertial reference frame in SP3-d files at 30sec rate.

3 CONTENTS OF THE TEST DATA PACKAGE

The test dataset in this package corresponds to a Nominal NRT Global/Regional processing Scenario referred to as TS-NO0110. Test dataset are provided for both summer and winter scenario.

3.1 Summer Scenario

L1B output products

ID	Coverage / Validity	Comments
[TS-NO0110-O-L1B]	Date: 2007-09-12 Start time: 08:40:10 UTC End time: 12:18:31 UTC	

Table 2: RO L1B data – summer scenario

Auxiliary output data

ID	Coverage / Validity	Comments
[AUX_LOC_]	Start date: 2007-09-11 Start time: 00:04:46 UTC End date: 2007-09-12 End time: 23:13:46 UTC	Available in [TS-NO0110-I-AUX]
[AUX_ZGD_]	Date: 2007-09-12 Start time: 00:01:46 UTC End time: 21:01:46 UTC	Available in [TS-NO0110-I-AUX] Even if the filename of the last file in the dataset indicates 21:01:46 UTC as end time, internally data are available up to 20:11:46.

Table 3: Auxiliary Output data – summer scenario

3.2 Winter Scenario

L1B output products

ID	Coverage / Validity	Comments
[TS-NO0110-O-L1B]	Date: 2008-02-23 Start time: 08:41:52 UTC End time: 10:40:53 UTC	

Table 4: RO L1B data – Winter Scenario

Auxiliary output data

ID	Coverage / Validity	Comments
[AUX_LOC_]	Start date: 2008-02-22 Start time: 00:04:46 UTC End date: 2008-02-23 End time: 23:16:46 UTC	Available in [TS-NO0110-I-AUX]
[AUX_ZGD_]	Date: 2008-02-23 Start time: 00:01:46 UTC End time: 21:01:46 UTC	Available in [TS-NO0110-I-AUX] Reconstructed Zenith GNSS data, stored in hourly RINEX files Even if the filename of the last file in the dataset indicates 21:01:46 UTC as end time, internally data are available up to 20:11:46.

Table 5: Auxiliary output data – Winter scenario

3.3 Input auxiliary data

Additionally, the following input auxiliary data are available for the summer and winter scenarios:

- [AUX_GOC_]: contains the GNSS Orbits and Clocks
- [AUX _EOP_]: contains the Earth Orientation Parameters
- [AUX _CCDB]: contains the relevant information on where the zenith/velocity/anti-velocity antenna phase centres and the satellite centre of mass are located in the satellite reference frame.

Such auxiliary data are provided with the format, frequency, coverage, etc. as specified in the EPS-SG RO Level 1b Auxiliary Data Specification V4B document. Relevant information is summarized in Annex A.

All these auxiliary data are the main input for running a Precise Orbit Determination for EPS-SG A1. The output of the POD as generated by our processor is available in AUX_LOC_. This data is also provided in the test data package (see Table 3 and Table 5).

As a side note, the same AUX_GOC_, AUX_LOC_ and AUX_ZGD_ can be used for computing the Total Electron Content above the satellite, allowing also interested users in developing algorithms for ionosphere / plasmasphere monitoring.

ANNEX A – AUXILIARY DATA SUMMARY SHEETS

The majority of the auxiliary input file for the processing of the Radio Occultation data generated in the framework of the EPS-SG mission are provided by the Radio Occultation Support Network (RSN). Data are provided to EUMETSAT with agreed timings, which are reported in the following table. Timings associated to generated auxiliary output files are shown there as well.

Product	Timing specification	value	Name
RSN	Past overlap	27:50 hours	RSN_P
RSN	Updated period interval	10 min	RSN_Up
RSN	Latency†	6.5 min	RSN_L
RSN	Timeliness††	16.5 min	RSN_T
RSN	Generation Frequency	10 min	RSN_GF
RSN	Future overlap	12 hours	RSN_F
RSN	Orbit and clock Sampling Rate	30 sec	RSN_SR
RSN	GNSS Navbit Updated period interval	10 min	GNB_Up
RSN	GNSS Navbit Past overlap	1 min	GNB_P
RSN	Earth Orientation Parameters Past overlap	4 days before the middle of RSN_Up	EOP_P
RSN	Earth Orientation Parameters Future overlap	3 days after the middle of RSN_Up	EOP_F
Solar Activity File	Past Overlap	24 hours	SOA_P
Solar Activity File	Future Overlap	3 days	SOA_F
LEO Orbit and Clocks Bias	Past overlap	24 hours	POD_C
LEO Orbit and Clocks Bias	Delta coverage (Future overlap)	3 hours	POD_D
LEO Orbit and Clocks Bias for Reprocessing	Past overlap	27 hours	LOC_P
LEO Orbit and Clocks Bias for Reprocessing	Future overlap	3 hours	LOC_F
LEO Orbit and Clocks Bias for Reprocessing	Generation Frequency	24 hours	LOC_GF
Zenith GNSS Data	Generation Frequency	1 hour	ZGD_F

† Since the RO-L1B-PGF does not interface directly with the RSN, the latency here defined takes into account the processing time at RSN premises and the overall transfer time from RSN to the RO-L1B-PGF.

†† Timeliness is defined as the interval from the start of the Updated period interval to the time when the products are available in input to the RO-L1B-PGF for processing.

The following tables provide information about format, frequency, coverage (i.e. validity) of the auxiliary files

- AUX_LOC
- AUX_ZGD
- AUX_GOC
- AUX_EOP
- AUX_CCDB

included in the delivered EPS-SG RO Test Data version 2.1.

LEO Orbit and Clock Bias (AUX_LOC):

Name	LEO Orbit and Clock Bias
Description	Metop-SG orbit and clock biases estimated and predicted by the POD software
Example of Filename	SGA1_RO__1B_AUX_LOC__G_S20220727120000Z_E20220728150000Z_G20220728123400Z_PDP__OPE_OPER[_<FreeText>].SIP
Spacecraft	SG(A|B)[1-3]
Auxiliary Data ID (ADF-ID)	RO__1B_AUX_LOC_
Source	PDP_
Members	1
Example of internal filename	SGA1_RO__1B_AUX_LOC__G_S20220727120000Z_E20220728150000Z_G20220728123400Z_PDP__OPE_OPER[_<FreeText>].sp3
Format of internal file (data file)	SP3-d [SP3-d]
Auxiliary Data Size	~ 800 kB
Generation Frequency	every POD run
Validity	• Start Validity: POD_C before the last available zenith measurement epoch in the input data • Stop Validity: The last processed measurement epoch + POD_D (predicted orbit) • Validity Interval: POD_C + POD_D.

Zenith GNSS Data (AUX_ZGD):

Name	Zenith GNSS Data
Description	GNSS standard observables acquired from the zenith antenna
Example of Filename	SGA1_RO__1B_AUX_ZGD__R_S20220728130000Z_E20220728140000Z_G20220728143400Z_PDP__OPE_OPER[_<FreeText>].SIP
Spacecraft	SG(A|B)[1-3]
Auxiliary Data ID (ADF-ID)	RO__1B_AUX_ZGD_
Source	PDP_
Members	1
Example of internal filename	SGA100EUM_R_20222091300_01H_01S_MO.rnx
Format of internal file (data file)	RINEX [RINEX]
Auxiliary Data Size	~6 MB
Generation Frequency	1 per hour
Validity	being an hourly file, the validity is defined as: • Start Validity: start of the coverage information • Stop Validity: end of the coverage information • Validity Interval: one hour

GNSS Orbits and Clock Biases (AUX_GOC):

Name	GNSS Orbits and Clock Biases
Description	**[RSNvxx.yy.zz]Estimated and propagated orbits and clock biases of** all GNSS satellites
Example of Filename	SG___RO__1B_AUX_GOC____S20220728110000Z_ E20220729230000Z_G20220729110300Z_RSN__OPE_OPER [_<FreeText>].SIP
Spacecraft	SG__
Auxiliary Data ID (ADF-ID)	RO__1B_AUX_GOC_
Source	RSN_
Members	1
Example of internal filename	SG___RO__1B_AUX_GOC____S20220728110000Z_ E20220729230000Z_G20220729110300Z_RSN__OPE_OPER [_<FreeText>].sp3
Format of internal file (data file)	SP3-d [SP3-d]
Auxiliary Data Size	~ 35 MB
Generation Frequency	every 10 min
Validity	• Start Validity: start of RSN_Up - RSN_P • Stop Validity: end of RSN_Up + RSN_F • Validity Interval: RSN_P + RSN_Up + RSN_F

GNSS Earth Orientation Parameters (AUX_EOP):

Name	Earth Orientation Parameters
Description	[RSNvxx.yy.zz]Time series of EOPs
Example of Filename	SG___RO__1B_AUX_EOP____S20220727225500Z_ E20220730225500Z_G20220729110300Z_RSN__OPE_OPER [_<FreeText>].SIP
Spacecraft	SG__
Auxiliary Data ID (ADF-ID)	RO__1B_AUX_EOP_
Source	RSN_
Members	1
Example of internal filename	SG___RO__1B_AUX_EOP____S20220727225500Z_ E20220730225500Z_G20220729110300Z_RSN__OPE_OPER [_<FreeText>].txt
Format of internal file (data file)	ASCII, similar to [EOP_DR]
Auxiliary Data Size	~ 3.0 kB
Generation Frequency	every 10 min
Validity	• Start Validity: EOP_P days before the file generation time (always at 00:00:00 or 06:00:00 or 12:00:00 or 18:00:00 (UTC), depending on the generation time itself) • Stop Validity: EOP_F days after the file generation time (always at 00:00:00 or 06:00:00 or 12:00:00 or 18:00:00 (UTC), depending on the generation time itself) • Validity Interval: EOP_P + EOP_F

RO Instrument Database (AUX_CCDB):

Name	RO Calibration and Characterization Database
Description	Set of instrument and satellite based corrective factors.
Example of Filename	SGA1_RO__1B_AUX_CCDB___S20210728120000Z_ ExxxxxxxxxxxxxZ_G20210727120000Z_CALV_OPE_OPER [_<FreeText>].SIP
Spacecraft	SG(A|B)[1-3]
Auxiliary Data ID (ADF-ID)	RO__1B_AUX_CCDB
Source	CALV
Members	1
Example of internal filename	SGA1_RO__1B_AUX_CCDB___S20210728120000Z_ ExxxxxxxxxxxxxZ_G20210727120000Z_CALV_OPE_OPER [_<FreeText>].nc
Format of internal file (data file)	NetCDF-4, schema A.3
Auxiliary Data Size	~ 60 kB

This is a NetCDF file, and includes the following two groups inside:

- *icdb* containing parameters from the original instrument characterization database.
- *scdb* containing parameters from the original satellite characterization database.

The long name attribute associated to the variables inside each group provides a self-explanation of the variable content.