SMOS L1 Auxiliary Data Format Specification

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1. INTRODUCTION

1.1. Purpose and Scope

This document describes the format of the SMOS Auxiliary data products, which shall be needed during the processing of SMOS data. In the same approach as with the L1 Product format document [RD.08], chapter 2 presents a brief introduction to the L1 Processor, and chapter 3 introduces the generic baseline adopted for the format.

Chapter 4 presents the contents and format of all different auxiliary files considered in the processing, while chapter 5 provides an estimate on the product sizes based on the contents presented.

1.2. Acronyms and Abbreviations

BFP	Best Fit Plane
DBL	Data Block
DGG	Discrete Global Grid
DSD	Data Set Descriptor
FEP	Front-End Processor
FOS	Flight Operations Segment
FTT	Flat Target Transformation
HKTM	Housekeeping Telemetry
IGRF	International Geomagnetic Reference Field
IRI	International Reference Ionosphere
ISP	Instrument Source Packet
LSB	Least Significant Bit
MPH	Main Product Header
MSB	Most Significant Bit
NDN	Noise Distribution Network
NIR	Noise Injection Radiometer
PMS	Power Measurement Signal
SPH	Specific Product Header
TEC	Total Electron Content
UTC	Universal Time
XML	eXtensible Markup Language

For the complete list of acronyms, please refer to the "Directory of Acronyms and abbreviations" [RD.05].

1.3. Applicable and Reference Documents

1.3.1. Applicable Documents

Ref.	Code	Title	Issue
AD.1	SO-SOW-CASA-PLM-0855	Level 1 Processor Prototype Development Phase 3, Support and Analysis Activities. Statement of Work	01
AD.2	SO-RS-ESA-PLM-0003	SMOS System Requirements Document	3.0
AD.3	SMOS-GS-IDR-TR-005	Input Output Data Definition SMOS Ground Segment	2.1
AD.4	ECSS-E-40B	ECSS E-40 Software Engineering Standards	
AD.5	PE-TN-ESA-GS-001	Earth Explorer Ground Segment File Format Standard	1.4

Table 1: Applicable Documents

1.3.2. Reference Documents

Ref.	Code	Title	Issue
RD.01	SO-TN-GMV-PLM-0003	SMOS End-to-End Performance Simulator Architectural and Detailed Design Document (AD/DD)	4.1
RD.02	SMOS-DMS-TN-2300	SMOS L1 Input Data Description Report	1.2
RD.03	SO-TN-ESA-GS-1250	SMOS Product Definition	1.4
RD.04	SO-TN-UPC-PLM-01	IN-ORBIT CALIBRATION PLAN	3.3
RD.05	SO-LI-CASA-PLM-0094	Directory of Acronyms and abbreviations	
RD.06	SO-TS-HUT-NIR-0005	NIR Calibration and Characterisation Plan	05E
RD.07	SO-TN-UPC-PLM-0019	SMOS In-Orbit Calibration Plan. Phase C-D	1.5
RD.08	SO-IS-DME-L1PP-0002	SMOS L1 Product Format	2.3
RD.09	SO-TN-DME-L1PP-0024	SMOS L1 Full Polarisation Data Processing	1.6
RD.10	SO-TN-DME-L1PP-0011	SMOS L1 Processor Algorithm Theoretical Baseline	2.9
RD.11	SO-TN-DME-L1PP-0009	SMOS L1 Processor L1b Detailed Processing Model	2.4
RD.12	SO-TN-GMV-PLM-0002	Technical Note on Galactic Poles Pointing for Calibration	2.0

Ref.	Code	Title	Issue
RD.13	SMOS-DMS-TN-5100	Technical Note on Strip Adaptive processing	1.2

Table 2: Reference Documents

2. SMOS L1 PROCESSOR

The SMOS Level 1 Processor shall convert the extracted Level 0 data or raw data into brightness temperatures at H and V polarisation. There are three intended levels of Level 1 Data: L1a, L1b and L1c, which will comprise the whole Level 1 Processor content.

A simple context diagram is depicted in the following figure, showing the interfaces that the L1 processor may have. Assuming that the Level 0 processing is embedded in the Level 1 processor, the inputs would be the SMOS raw data coming from the Front End Processor located at the SMOS PDPC, and the auxiliary data needed, such as calibration tables and TEC models. Ancillary data needed for internal processing is obtained from the raw data of the HKTM. The outputs would be the intermediate and final products produced all along the processing steps.

By convention, ancillary data is produced on board the satellite, and is formed by data not part of the scientific data, like HKTM. When the ancillary data is received on the ground, and packaged with the Ground Segment header (according to Earth Explorer File format) it becomes Auxiliary Data.

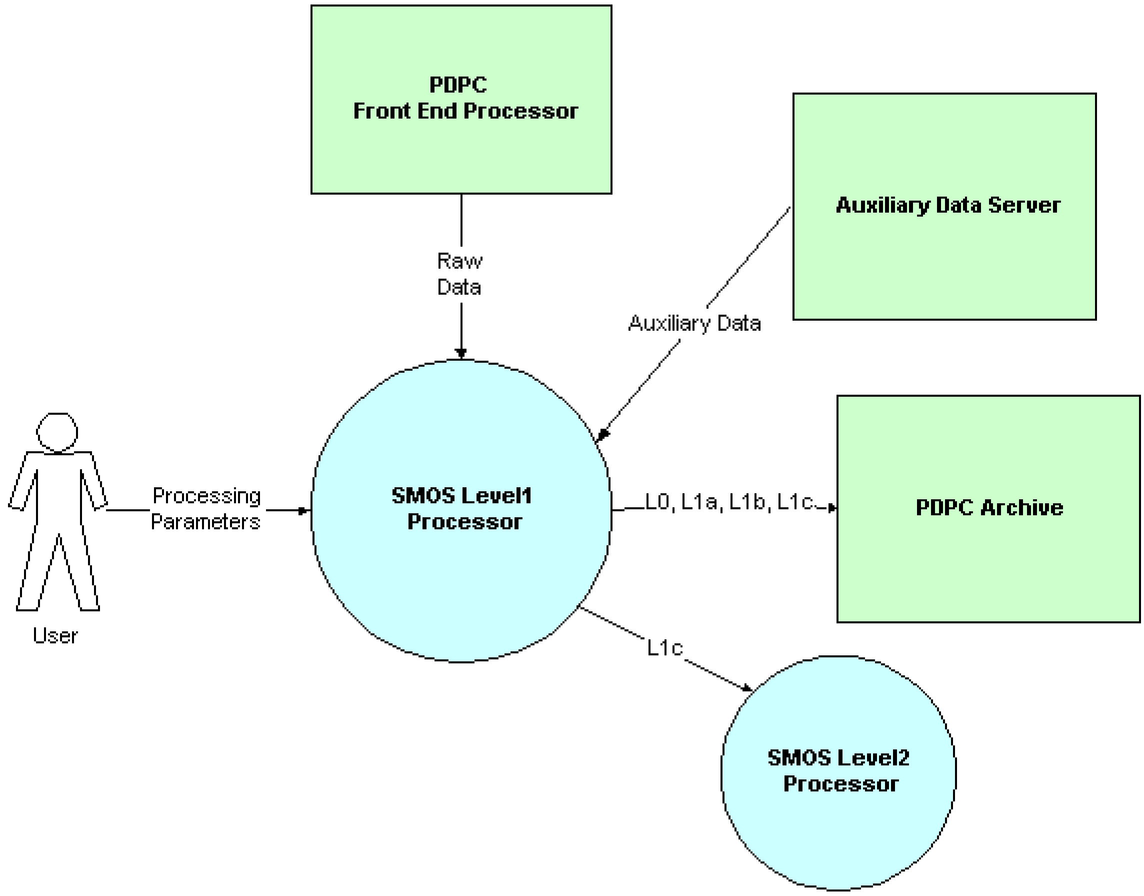

Figure 1: SMOS L1 Context Diagram

3. ADF GENERAL FORMAT DESCRIPTION

The format shall be in accordance to Earth Explorer standards, including ASCII and binary data in the XML (eXtensible Markup Language) standard.

The format information shall be an inherent part of the XML Schemas, so the product files shall be auto-contained. This means that any API used to read them will not need any a priori information on their possible contents, but shall be able to know it by using the schemas.

3.1. File Name

According to the ESA Earth Explorer File Format Standard, *files shall be named using a fixed set of elements, each of fixed size, separated by underscores "_"*. The maximum size for any given file name shall be smaller than 64 characters.

The Logical File Name is to be of the following structure:

MM_CCCC_TTTTTTTTTT_<Instance ID>

Where each of the elements will be as follows:

Table 3: Meaning of Logical File Name elements

Naming Element	Description	Format
MM	**Mission ID.** This field will be '**SM**' for all SMOS products	2 characters Uppercase letters
CCCC	**File Class**. This element identifies the type of activity for which the file is to be used, namely which phase of the ground segment development or operations cycle (TD00 for Test Dataset, GSOV for GS Validation Test, OPER for Operation, REPR for Reprocessing, COMM for Commissioning Phase, GC00 for Ground Calibration phases…).	4 characters Uppercase letters or digits
TTTTTTTTTT	**File Type.** This element uniquely defines the file structure and should include: **File Category** These are the first 4 characters (3 characters plus underscore) and define the type of file (e.g. TLM for telemetry, MIR for MIRAS products, AUX for Auxiliary files) **Semantic Description**	10 characters Uppercase letters, digits or underscores "_"

Naming Element	Description	Format
	These are also 4 characters in size and provide description of the type of data represented (e.g. SC_D for Science Data at Dual-polarisation) **Product Level** The last 2 characters, it gives information on the level of data represented (e.g. 0_, 1b, 2_,)	
<Instance ID>	**Instance ID.** The role of this element is to avoid file name duplicates and add extra information that may prove useful for understanding the contents of the file. All files of the same File Category must have the same File Instance ID format and should include one date and time element (Creation or Validity period) separated by a 'T' (e.g. 20040526T172800). If the file name still is not unique, a Version number should be added, starting in '1'and having as many digits as needed for the expected lifetime of operation of the mission. For the current L1 format, this Instance ID shall be modelled as a string of 41 characters containing the following information: ❑ Validity Start time: YYYYMMDDTHHMMSS (15 char) ❑ Underscore: _ (1 char) ❑ Validity Stop time: YYYYMMDDTHHMMSS (15 char) ❑ Underscore: _ (1 char) Version: %08d (8 char)	Maximum 41 characters Uppercase letters, digits or underscores "_"

It must be clearly stated, that the underscore character "_" shall be used also as separator between naming elements. As a guideline, [AD.5] states that a typical Earth Explorer mission should have between 5 and 10 File Categories and 1 to 3 different File Instance ID shapes.

The Logical File Names of the SMOS Products and its Auxiliary Data Files (ADF) are listed in the following table. The sections classified with 'xxxx' are yet to be defined.

Table 4: Logical File Names of SMOS Auxiliary Data Files

Type of Data		File Name prefix convention
ADF	Level 0 Configuration file	SM_xxxx_AUX_CNF_L0<ID>
	PMS Characterisation tables	SM_xxxx_AUX_PMS___<ID>
	NIR Characterisation tables	SM_xxxx_AUX_NIR___<ID>
	Relevant S-parameters of MIRAS (noise distribution networks and switch)	SM_xxxx_AUX_SPAR__<ID>
	Receivers Characterisation (ohmic efficiency and absolute phase)	SM_xxxx_AUX_LCF___<ID>
	Normalised power and phase patterns of all antennas (where ## indicates the receiver numbering)	SM_xxxx_AUX_PATT##<ID>
	Failing Components Table	SM_xxxx_AUX_FAIL__<ID>
	Best Fit Plane	SM_xxxx_AUX_BFP___<ID>
	Discrete Global Grid	SM_xxxx_AUX_DGG___<ID>
	L1c Pixel Mask	SM_xxxx_AUX_MASK__<ID>
	Land/Sea Mask	SM_xxxx_AUX_LSMASK<ID>
	Galaxy L-band Map	SM_xxxx_AUX_GLXY__<ID>
	Vertical Total Electron Content Map	SM_xxxx_AUX_VTEC__<ID>
	Geomagnetic model	SM_xxxx_AUX_IGRF__<ID>
	Sun Brightness Temperature Map Model	SM_xxxx_AUX_SUNT__<ID>
	Moon Brightness Temperature Map Model	SM_xxxx_AUX_MOONT_<ID>
	Earth Brightness Temperature Map Model	SM_xxxx_AUX_ERTHT_<ID>
	PLM Characterisation Table	SM_xxxx_AUX_PLM___<ID>
	RFI sources Map	SM_xxxx_AUX_RFI___<ID>
	Time correlation definition	SM_xxxx_AUX_TIME__<ID>
	G Matrix definition	SM_xxxx_AUX_GMAT__<ID>
	J Matrix Definition	SM_xxxx_AUX_JMAT__<ID>
	Apodisation Window Coefficients	SM_xxxx_AUX_APOD__<ID>
	Flat Target Transformation Measurements	SM_xxxx_AUX_FLATT_<ID>
	Bistatic Scattering Coefficients	SM_xxxx_AUX_BSCAT_<ID>
	Instrument Mispointing Angles	SM_xxxx_AUX_MISP__<ID>
	Instrument Baseline Weights	SM_xxxx_AUX_BWGHT_<ID>

All Physical Files related to the same Logical File share the same file name, changing only the extension. A single file merging Header and Data Block should have the extension .EEF. If the files are distributed separately, the Header File should bear the extension .HDR and the Data Block File the extension .DBL.

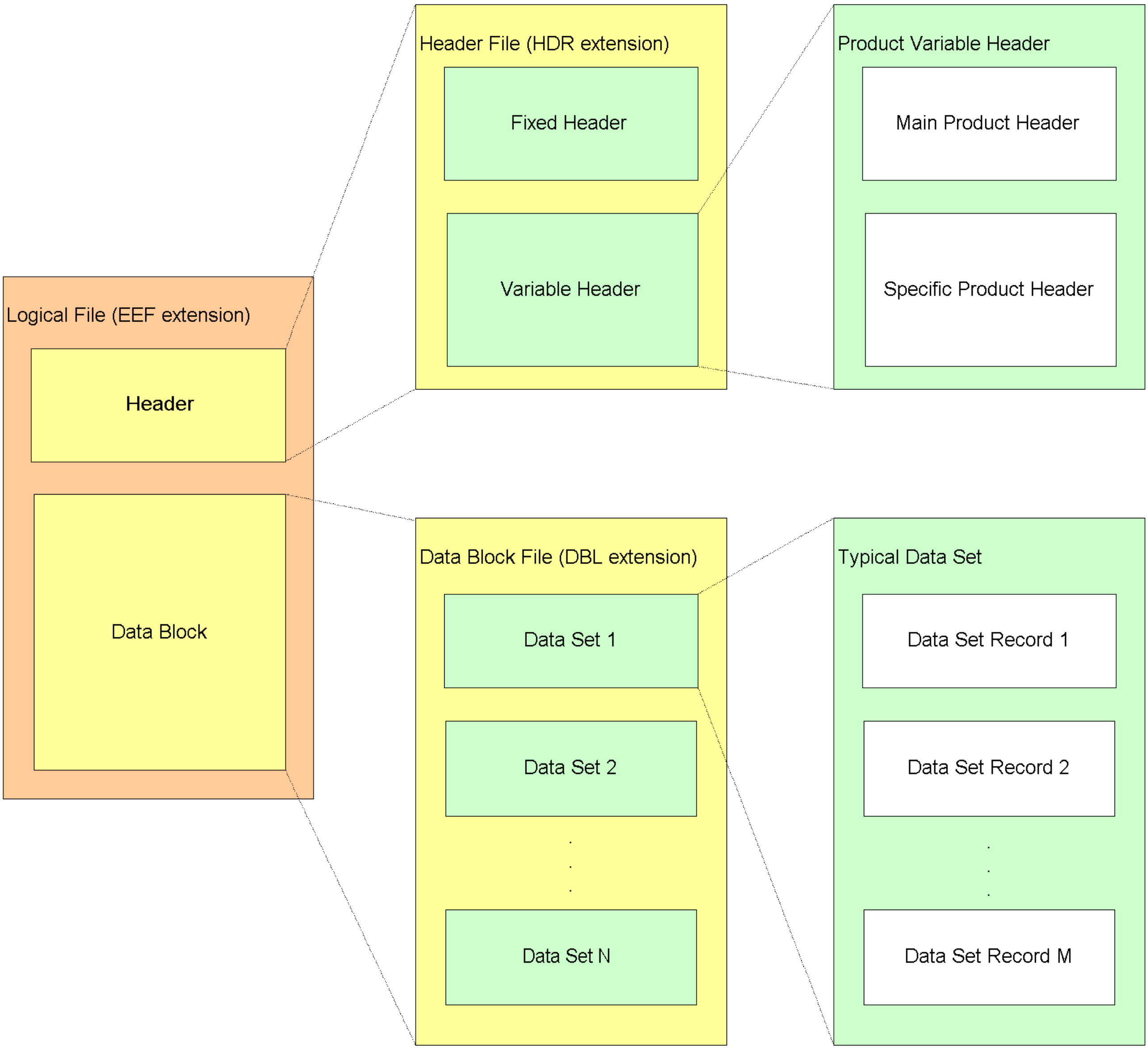

Figure 2: Logical File Decomposition

In the L1 Processor Prototype it shall be possible to use as input either format of the product files: the complete hybrid binary-XML file with .EEF extension, or the combination of both header and data block files. The binary contents of the product file shall not be enclosed within XML tags. This means that the complete product is built from a fully defined XML header file and a concatenated pure binary file. For the case of auxiliary products, in most cases the contents shall be ASCII XML instead of binary, in which case the structure is simplified. Other products like the antenna patterns or the G matrices shall be in hybrid binary-XML format due to the amount of data presented.

3.2. Header File

The Header File is constituted by two parts, a **Fixed Header** and a **Variable Header**.

3.2.1. Fixed Header

Fixed header is common to all Earth Explorer missions and is defined in the File Format Standards [AD.5] document. Its format is described in [RD.03] and it shall be the same for all files of the SMOS mission.

3.2.2. Variable Header

The Variable Header is specific to each SMOS file and is listed in detail in the following chapters.

It is constituted by a Main Product Header (MPH) and a Specific Product Header (SPH).

3.3. ADF Characterisation

The characterisation of all ADF is reflected in the following summary table, where information is presented for relevant topic such as:

- Update frequency: How often each file is expected to change
- File size: Expected file size of each file
- File format: Whether its contents shall be in ASCII XML or binary
- ADF Source: On-ground calibration EADS CASA Espacio, On-ground calibration ESA, Geophysical institute, ESA, ESL,...etc

Table 5: SMOS Auxiliary Data Files Characterisation

File Type	Update Frequency	Approx. File Size	File Format	Source
AUX_CNF_L0	1-10 times in Mission	10 KB	ASCII XML	L1 Configuration
AUX_PMS___	1-10 times in Mission	150 KB	ASCII XML	On-ground cal CASA
AUX_NIR___	1-10 times in Mission	50 KB	ASCII XML	On-ground cal CASA
AUX_PLM___	None	10 KB	ASCII XML	On-ground cal CASA
AUX_SPAR__	None	500 KB	ASCII XML	On-ground cal CASA
AUX_LCF___	None	100 KB	ASCII XML	On-ground cal CASA
AUX_PATT##	None	6 MB (for each receiver)	Binary	On-ground cal CASA
AUX_FAIL__	1-10 times in Mission	50 KB	ASCII XML	CEC, ESA
AUX_BFP___	1-10 times in Mission	10 KB	ASCII XML	On-ground cal CASA,

File Type	Update Frequency	Approx. File Size	File Format	Source
				CEC
AUX_DGG___	None	40 MB	Binary	L1 Configuration
AUX_LSMASK	None	13 MB	Binary	ESA
AUX_MASK__	1-10 times in Mission	13 MB	Binary	ESA, ESL
AUX_GLXY__	1-10 times in Mission	10 MB	Binary	ESA
AUX_SUNT__	Update as L1 product, but only used in reprocessing	300 KB	ASCII XML	CEC, ESL, L1 Configuration
AUX_MOONT_	1-10 times in Mission	300 KB	ASCII XML	CEC, ESL, L1 Configuration
AUX_ERTHT_	1-10 times in Mission	300 KB	ASCII XML	CEC, ESL, L1 Configuration
AUX_VTEC__	Every 24h	20 KB	ASCII XML	Geophysical Institute (UPC), ESA
AUX_IGRF__	Expected update in 2010	50 KB	ASCII XML	Geophysical Institute
AUX_APOD__	None	300 KB	ASCII XML	L1 Configuration
AUX_GMAT__	Bi-weekly	8 GB	Binary	L1 Nominal Output, ESL
AUX_JMAT__	Bi-weekly	1.4 GB	Binary	L1 Nominal Output, ESL
AUX_RFI___	Monthly	13 MB	Binary	CEC, ESL, ESA
AUX_TIME__	1-10 times in Mission	10 KB	ASCII XML	CEC, ESL, L1 Configuration
AUX_FLATT_	Bi-weekly	400 KB	Binary	L1 Nominal Output, ESL
AUX_BSCAT_	1-10 times in Mission	300 KB	Binary	CEC, ESL, ESA
AUX_MISP__	1-10 times in Mission	10 KB	ASCII XML	On-ground cal CASA, CEC
AUX_BWGHT_	1-10 times in Mission	50 KB	ASCII XML	On-ground cal CASA, CEC

4. AUXILIARY DATA FILES

4.1. Generic Guidelines

Each Product File is composed by the following components:

- XML Header
- XML/Binary Data Block

The first block is written in XML ASCII format, while the last one contains the ASCII/Binary data that is the bulk of the product. There are no ADF in this mission which use variable sized Data Set Records.

As described in [RD.08], the XML Header is formed by a Fixed Header and a Variable Header, this last one containing the Main Product Header and Specific Product Header.

In most Auxiliary Data Files, the major part of the fields set in the MPH and SPH shall not be used, in which case they shall be set to default values.

A validation schema shall be available for all product headers in order to validate the contents of each file.

4.1.1. XML Main Product Header

The MPH structure is common to all SMOS L1 product files and ADF. The table presented below is the same as table 8 of [RD.08], but containing some indications on how to fill some fields for ADF products.

Table 6: L1 Data Common MPH

Field	Tag name	Description	Units	Bytes	Format
		Product Identification Info			
#01	Product	File Name Left justified and padded with blanks	Tag N/A	62	See 3.1
#02	Proc_Stage_Code	Processing Stage Code OPER = Routine Operations TEST = Test RPRO = Reprocessing NRET = Near Real Time…	Tag N/A	4	4*uc
#03	Ref_Doc	Ref. PDPC doc describing the product (this document)	Tag N/A	23	23*uc
		XML Information			

Field	Tag name	Description	Units	Bytes	Format
#04	Header_Size	Header Size in bytes Used by the read/write API, in order to extract the header and make it readable with an XML schema	Tag bytes	10	10*uc
#05	Validation_Schema	Data Block Validation Schema Validation schema used to generate the product	Tag N/A	31	31*uc
		Data Processing information			
#06	Acquisition_Station	Acquisition Station ID. Left justified with blanks. Not used in ADF, filled with blanks	Tag N/A	20	20*uc
#07	Proc_Centre	ID code of the Processing Centre that has generated the product	Tag N/A	6	6*uc
#08	Proc_Time	UTC processing time. Time at which the product was generated.	Tag UTC	30	30*uc UTC=yyyy-mm-ddThh:mm:ss.uuuuuu
#09	Proc_Version	L1 Processor Software version name and number. Left justified with unused characters filled with blanks.	Tag N/A	14	14*uc ProcessorName(10*uc)/VV.rr(4*uc)
		Product Data Time Information			
#10	Sensing_Start	UTC Start Time of data sensing (first data package or scene) Not used in ADF, filled with blanks	Tag UTC	30	30*uc UTC=yyyy-mm-ddThh:mm:ss.uuuuuu

Field	Tag name	Description	Units	Bytes	Format
#11	Sensing_Stop	UTC Stop Time of data sensing (last data package or scene) Not used in ADF, filled with blanks	Tag UTC	30	30*uc UTC=yyyy-mm-ddThh:mm:ss.uuuuuu
		Orbit Information			
#12	Phase	Phase number. If not used set to +000. Not used in ADF, set to +000	Tag N/A	1	uc
#13	Cycle	Cycle number. If not used set to +000 Not used in ADF, set to +000	Tag N/A	4	%+04d
#14	Rel_Orbit	Relative orbit at sensing start time within the orbit repeat cycle. If not used set to +00000 Not used in ADF, set to +00000	Tag N/A	6	%+06d
#15	Abs_Orbit	Absolute orbit at sensing start time. If not used set to +00000. First crossing of ascending node after launch determines the beginning of absolute orbit 1. Not used in ADF, set to +00000	Tag N/A	6	%+06d
#18	X_Position	X Position in Earth Fixed Reference Not used in ADF, set to +0000000.000	Tag (m)	12	%+012.3f
#19	Y_Position	Y Position in Earth Fixed Reference Not used in ADF, set to +0000000.000	Tag (m)	12	%+012.3f

Field	Tag name	Description	Units	Bytes	Format
#20	Z_Position	Z Position in Earth Fixed Reference Not used in ADF, set to +0000000.000	Tag (m)	12	%+012.3f
#21	X_Velocity	X Velocity in Earth Fixed Reference Not used in ADF, set to +000.000000	Tag (m/s)	12	%+012.6f
#22	Y_Velocity	Y Velocity in Earth Fixed Reference Not used in ADF, set to +000.000000	Tag (m/s)	12	%+012.6f
#23	Z_Velocity	Z Velocity in Earth Fixed Reference Not used in ADF, set to +000.000000	Tag (m/s)	12	%+012.6f
#24	Vector_Source	Source of the Orbit State Vector record IG = GPS FP = FOS predicted FR = FOS Restituted Not used in ADF, set to blanks	Tag N/A	2	2*uc
#25	Leap_UTC	UTC Time of the occurrence of the leap second. If a leap second occurred in the product window the field is set by a devoted function in the CFI EXPLORER_ORBIT library (see [EXPL_ORB-SUM] for details), otherwise it is set to 30 blanks. It corresponds to the time after the Leap Second occurrence (i.e. midnight of the day after the leap second) Not used in ADF, set to blanks	Tag UTC	30	30*uc UTC=yyyy-mm-ddThh:mm:ss.uuuuuu
Product Data Confidence and Size Information					

Field	Tag name	Description	Units	Bytes	Format
#26	Product_Confidence	Product confidence value. Enumerated (NOMINAL for no errors, DEGRADED for minor errors reported, ERROR, SPARE…) Not used in ADF, set to blanks	Tag N/A	10	uc
#27	Total_Size	Total Size of the Data Product (# bytes DBL+SPH+MPH)	Tag (bytes)	21	%021d

4.1.2. XML Specific Product Header

Table 7: L1 Data SPH

Field #	Tag name	Description	Units	Bytes	Format
		Product Description and Identification			
#01	SPH_Descriptor	Name describing SPH. See Table 8	Tag	28	28*uc
		Product Time Information			
#02	Time_Info	Time Information. XML structure containing the variables described below	Tag N/A		
#03	Validity_Start	Start time of validity period for auxiliary file	Tag UTC	30	30*uc UTC=yyyy-mm-ddThh:mm:ss.uuuuuu
#04	Validity_Stop	Stop time of validity period for auxiliary file	Tag UTC	30	30*uc UTC=yyyy-mm-ddThh:mm:ss.uuuuuu
		Dataset Description			

Field #	Tag name	Description	Units	Bytes	Format
(fields #06 to #14 are the same ones referred in the Dataset Description section in table 9 of [RD.08])					
#06	List_of_Data_Set	List containing the number of Data_Set, with "count" field as attribute. It is an XML structure containing a number of the Data_Set structures	Tag	2	
#07	Data_Set	XML structure containing the variables described below	Tag		
#08	Data_Set_Name	Name describing the Data Set. See table 9 of this document and table 12 of [RD.08]	Tag N/A	28	28*uc
#09	Data_Set_Type	Type of Dataset: M for measurement R for reference	Tag N/A	1	uc
#10	Ref_Filename	Name of reference file in type R Data sets	Tag N/A	62	62*uc
#11	Num_MDR	Number of measurement records (scenes or integration time) in the Data Set (filled only for Measurement Data Sets)	Tag N/A	6	%+06d
#12	MDR_Size	Size in bytes of each binary Measurement data set record	Tag bytes	10	%+010d
#13	MDR_Offset	Offset in bytes since the beginning of the product file until the beginning of the binary Data Set in Measurement records	Tag bytes	10	%+010d
#14	Byte_Order	Type of ordering of the binary data. "3210" for big-endian, "0123" for little-endian, "2301" for middle-	Tag N/A	4	4*uc

Field #	Tag name	Description	Units	Bytes	Format
		endian, “0000” for Not applicable			

SPH names accepted shall make reference to the type of product that contains the SPH. The following table provides a summary of SPH names for SMOS Auxiliary data files:

Table 8: SPH names

SPH NAME	Description
MIRAS_Aux_Level0	SPH for Auxiliary product containing the L0 Configuration parameters
MIRAS_Aux_PMS	SPH for Auxiliary product containing on-ground characterisation of PMS, including sensitivity of parameters to physical temperature
MIRAS_Aux_NIR	SPH for Auxiliary product generated from on-ground (initially) and external (in-flight) characterization of the NIR, using MIRAS output during an external target calibration (Not part of L1 Processing, this type of calibration is to be performed out of PLPC)
MIRAS_Aux_PLM	SPH for Auxiliary product generated from on-ground characterisation of the PLM, including thermistor parameters, receiver’s exact position, Xband parameters, etc.
MIRAS_Aux_SPARAM	SPH for Auxiliary product containing on-ground characterisation of the S-parameters
MIRAS_Aux_LICEF	SPH for Auxiliary product containing on-ground characterisation of receivers’ efficiencies
MIRAS_Aux_ANT_PATTERNS	SPH for Auxiliary product containing on-ground characterisation of receivers’ amplitude and phase patterns and maximum directivity
MIRAS_Aux_FAIL	SPH for Auxiliary product containing default failures to be taken into account on nominal L1 processing
MIRAS_Aux_BFP	SPH for Auxiliary product containing receivers’ derived Best Fit Plane
MIRAS_Aux_GRID	SPH for Auxiliary product containing the Earth Fixed Grid on which L1c products shall be expressed
MIRAS_Aux_TEC	SPH for Auxiliary product containing Total Electron Content values to compute Faraday rotation angle
MIRAS_Aux_GEOMAGNETIC	SPH for Auxiliary product containing the definition of the Earth’s magnetic field to compute the rotation due to change of reference frame from satellite to

SPH NAME	Description
	ground
MIRAS_Aux_GALAXY	SPH for Auxiliary product containing the L-band measurements of the Sky
MIRAS_Aux_PIXELMASK	SPH for Auxiliary product containing the flagging of pixels for use in L1c land or sea products
MIRAS_Aux_LANDSEAMASK	SPH for Auxiliary product containing the Land/Sea mask of pixels in the DGG
MIRAS_Aux_SUN	SPH for Auxiliary products containing the measured evolution of Sun Brightness Temperature along time
MIRAS_Aux_MOON	SPH for Auxiliary products containing the measured evolution of Moon Brightness Temperature along time
MIRAS_Aux_EARTH	SPH for Auxiliary products containing a simple modelling of Earth Brightness Temperature
MIRAS_Aux_RFI	SPH for Auxiliary products containing known sources of Radio Frequency Interference in MIRAS bandwidth, in the same grid as the auxiliary grid being used
MIRAS_Aux_APODISATION	SPH for Auxiliary products containing the element-by-element definition of the Apodisation Window in the u,v plane.
MIRAS_Aux_G_MATRIX	SPH for Auxiliary products containing the element-by-element definition of the System Response Matrices for each polarisation.
MIRAS_Aux_J_MATRIX	SPH for Auxiliary products containing the element-by-element definition of the Image Reconstruction J matrix.
MIRAS_Aux_TIME	SPH for Auxiliary products containing the time correlations between UTC, GPS, TAI and UT1
MIRAS_Aux_Flat_Target_Transf	SPH for Auxiliary products containing the averaged correlations measured during deep Sky measurement, to be used in FTT.
MIRAS_Aux_ Scattering_Coef	SPH for Auxiliary products containing the Bistatic Scattering Coefficients used in Sun glint correction.

4.1.3. XML Data Sets

The Reference Data Sets shall contain a filename linking the product to a reference auxiliary file, to the originating sub-product and even to the ancillary calibration data. The values accepted are presented in table 12 of [RD.08].

The Measurement Data Sets shall contain binary contents as described in its associated XML schema, ranging from PMS gain and offset values to lat-lon coordinates of the Earth Fixed Grid. The currently valid values are presented in the following table.

Table 9: Measurement Data_Set names

Data_Set_Name	Description
L0_Configuration	Configuration parameters for L0 Processing
PMS	Coefficients to pass from PMS Voltage measurements to Power units (Gain and offset)
NIR	Coefficients to pass from NIR pulse length measurements to Antenna temperature (Gain and offset) and to use the NIR as a LICEF for baselines (retrieval of Tsys)
PLM	Coefficients to convert thermistor and x-band measurements into engineering units, as well as operational parameters of the Payload.
S_PARAMETERS	Scattering parameters of all possible connections in MIRAS.
LICEF	Efficiency of antennas and absolute phase
ANT_PATT	On-ground measured antenna patterns (amplitude and phase) in a defined antenna fixed grid
FAILURES	Known failures to be taken into account in L1 processing
BFP	Estimated orientation of Best Fit Plane with regard to MIRAS pointing direction
DGG	Earth Fixed Grid used for geolocalisation of L1c. Hexagonal ISEA, aperture 4, and resolution 9.
TEC	Total Electron Content
GEOMAGNETIC	Geomagnetic model coefficients
GALAXY_MAP	Galaxy L-band emission map/maps
L1C_PIXEL_MASK	L1c Pixel mask
LAND_SEA_MASK	Land/Sea mask

Data_Set_Name	Description
MEASURED_SUN	Measured Sun Brightness Temperatures
MEASURED_MOON	Measured Moon Brightness Temperature along time
EARTH_BT_MODEL	Modelling of Earth Brightness Temperature
RFI	Radio Frequency Interference mask in MIRAS bandwidth, in the same grid as the auxiliary grid being used
APODISATION	Apodisation window elements in a known configuration.
GMATRIX	G Matrix elements in a known configuration
JMATRIX	J Matrix elements in a known configuration
TIME	Time correlations between UTC, GPS, TAI and UT1
FTT	Averaged correlations in different polarisations measured during Flat Target Observation
SCATTERING	Bistatic Scattering Coefficients against polarisation, sun direction, observation angles and wind speed

4.2. Level 0 Configuration File

This file shall define the processing thresholds to be taken into account by the L0 Processor, when converting the raw data as produced by the FEP into consolidated L0 Products.

These L0 Products shall have associated quality flags, indicating errors in the ISP, or even missing ISP. The thresholds that define if the error flag is raised or not shall be defined in this file

4.2.1. Main Product Header

See 4.1.1.

4.2.2. Specific Product Header

See 4.1.2

4.2.3. Data set

This data set shall contain one Data Set Record with the thresholds for all type of errors that may be reported by the FEP, and also for those that may be detected at L0 processing. Its contents shall be referred in ASCII XML format.

Table 10: L0 Configuration Data Set Record

Field #	Tag name	Description	Units	Bytes	Size

Field #	Tag name	Description	Units	Bytes	Size
L0 Configuration					
#01	L0_Configuration	Name describing the Data Block. XML structure containing the variables described below	Tag		
#02	L0_Err_Threshold	Minimum acceptable threshold of quality checks that must be passed during the SP processing (max allowed +10000)	Tag (10^{-2} %)	6	%+06d
#03	Missing_ISP_Threshold	Minimum acceptable threshold of missing ISP against total expected ISP during the SP processing (max allowed +10000)	Tag (10^{-2} %)	6	%+06d
#04	Discarded_ISP_Threshold	Minimum acceptable threshold of discarded ISP against total ISP during the SP processing (max allowed +10000)	Tag (10^{-2} %)	6	%+06d
#05	RS_ISP_Threshold	Minimum acceptable threshold of ISP with Reed-Solomon correction against total number of ISP during the SP processing (max allowed +10000)	Tag (10^{-2} %)	6	%+06d
End of L0_Configuration structure					

4.3. PMS Characterisation tables

Conversion tables are used to convert PMS voltage telemetry values into power units. These shall be the measured System Temperatures used to normalise the calibrated visibilities. There is one of such voltage measurements per LICEF, which needs to be converted appropriately.

The **gain** of a diode is the increase in voltage, current and/or power and is expressed as a ratio of output voltage value to the corresponding input voltage value.

Offset is the difference between the measured output voltage and the expected output voltage computed as the gain multiplied by the System Temperature. Ideally, the output voltage should be the same as the input voltage but in reality it never is and the offset measures that difference.

The offset and gain will be extracted from this auxiliary file and used for the calculation of the output noise power of the receivers. There is one PMS per LICEF and NIR-LICEF, adding up to 72 different characterisations. These characterisations are dependant on the physical temperature of the PMS, which shall be measured and set in the ancillary data packet.

These offset and gain values should be measured by the MIRAS manufacturer and should be provided in an auxiliary file. It also provides the expected sensitivity of those values to physical temperature and second order terms (Flink). Offset and Gain parameters shall undergo continuous calibration while in-flight, during correlated noise injection. Physical temperature sensitivity parameters are not expected to drift, but since the diodes might deteriorate with time, there may be an update of this file.

As mentioned, during MIRAS operation, it is possible to characterise again the PMS response, using correlated Noise Injection. This calibration produces as intermediate output the calibrated measurements of gain and offset of each PMS, to be used for System Temperature computation. This data shall be consolidated into a L1 Auxiliary product, very similar to the one presented here.

4.3.1. Main Product Header

See 4.1.1.

4.3.2. Specific Product Header

See 4.1.2

4.3.3. Data set

This file contains a unique data set that shall contain the gain and offset information for all PMS, under different thermal conditions. Its contents shall be referred in ASCII XML format. The data set is formed by 1 Data Set Record with all the information.

Table 11: PMS Characterisation Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
PMS					
#01	PMS_Characterisation	Name describing the Data Set. XML structure containing the variables described below	Tag		
#02	List_of_PMS_Data	List containing the PMS data structures, with "count" field (count=72)	Tag	2	
PMS_Data structure (Repeated "count" times)					
#03	PMS_Data	XML structure containing the variables described below	Tag		

Field #	Tag name	Description	Units	Bytes	Size
#04	PMS_ID	PMS Unique identifier Format is XXYZZ, where: ❑ XX indicates the arm location (A_, AB, B_, BC, C_ or CA) ❑ Y indicates polarisation for NIR elements (H, V or _) ❑ ZZ indicates LICEF number in arm location (01, 02, 03,… 21) For example AB_03, CAH01, B__18	N/A	5	5 chars
#05	List_of_PMS_Characterisation_Data	List containing the gain and offset values against physical temperatures, with "count" field (count=3)	Tag		
PMS Characterisation Data (repeated "count" times)					
#06	PMS_Characterisation_Data	XML structure containing the variables described below	Tag		
#07	Temperature	Temperature at which the PMS coefficients were obtained	Tag K	6	%06.3f
#08	Gain	Gain coefficient for PMS identified before and at previous temperature.	Tag mV/K	10	%+010.4f
#09	Offset	Offset coefficient for PMS identified before and at previous temperature.	Tag mV	10	%+010.4f
#10	Trec_HAP	Receiver Noise temperature in HAP plane for PMS identified before and at previous temperature	K	8	%+08.3
#11	Trec_VAP	Receiver Noise temperature in VAP plane for PMS identified before and at previous temperature	K	8	%+08.3
End of PMS_Characterisation_Data structure					

Field #	Tag name	Description	Units	Bytes	Size
#~~10~~12	Gain_Sensitivity	Gain sensitivity coefficient for PMS gain against PMS physical temperature drifts.	Tag mV/ K^2	8	%+05.3e
#~~11~~13	Offset_Sensitivity	Offset sensitivity coefficient for PMS offset against PMS physical temperature drifts.	Tag mV/K	8	%+08.5f
#~~12~~14	PMS_Linearity	Term used to correct 2nd order response of each PMS (Flink).	Tag nV/ K^2	8	%+05.3e
#15	Trec_HAP_Sensitivity	Receiver Noise temperature sensitivity in HAP plane for PMS identified before and at previous temperature	K/K	8	%+08.5
#16	Trec_VAP_Sensitivity	Receiver Noise temperature sensitivity in VAP plane for PMS identified before and at previous temperature	K/K	8	%+08.5
End of PMS_Data structure					
End of PMS_Characterisation structure					

4.4. NIR Characterisation table

Conversion tables are used to convert NIR pulse length telemetry values into Brightness Temperature units and noise temperature whenever the LICEF-NIRs are operating like a nominal LICEF and providing correlations.

NIR measurements are used to obtain the measured Brightness Temperature at the zero-baseline used in the reconstruction process. There is one of such pulse length measurements per polarisation and NIR, which needs to be converted appropriately.

The following values have been presented in [RD.06] and it is expected that they be provided by the manufacturer and measured during on-ground calibration sessions. Their contents shall be set in this file so that any additional external characterisation may update them if required.

These values shall undergo an external calibration by deep Sky pointing, at which time they shall be updated in an L1a product. This external auxiliary file is left to accommodate for external calibrations performed outside of the L1 Processor.

Other ground characterisations shall measure the relevant parameters that allow the computation of the System Temperatures of the LICEF-NIR when they are working as nominal receivers in correlations.

4.4.1. Main Product Header

See 4.1.1.

4.4.2. Specific Product Header

See 4.1.2

4.4.3. Data set

This file contains a unique data set that contains the attenuation parameters for all NIR in different reference planes, as well as the correction factors established on-ground for the NIR responses. Its contents shall be referred in ASCII XML format. The data set is formed by 1 Data Set Record with all the information.

NIR parameters shall be characterised against physical temperature of each element, so that they can be interpolated to the operating temperature at the time of measurement. Further information shall be detailed when the new NIR calibration note is available.

All the description of reference planes (VIP, VAP…) mentioned within the table can be found in [RD.06].

Table 12: NIR Characterisation Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
NIR					
#01	NIR_Characterisation	Name describing the Data Set. XML structure containing the variables described below	Tag		
#02	List_of_NIR_Data	List containing the NIR data structures, with "count" field (count=3)	Tag	2	
NIR_Data structure (Repeated "count" times)					
#03	NIR_Data	XML structure containing the variables described below	Tag		
#04	NIR_ID	NIR Unique identifier	N/A	1	1 byte Integer formed number of NIR
#05	L_1_V	Attenuation (losses) between VAP and VAP2 (radiator of the antenna) at specified temperature	dB	4	4 bytes %04.2f

Field #	Tag name	Description	Units	Bytes	Size
#06	L_2_V	Attenuation (losses) between VAP2 and VIP (feed network of the antenna) at specified temperature	dB	4	4 bytes %04.2f
#07	L_NC_V	Attenuation (losses) between VIP and V-OPV (output connector) at specified temperature	dB	4	4 bytes %04.2f
#08	L_A_V	Attenuation (losses) between V-OPV and LV-VIP (input connector) at specified temperature	dB	4	4 bytes %04.2f
#09	L_DA_V	Attenuation (losses) between LV-VIP and LV-LCIP (switch output) at specified temperature	dB	4	4 bytes %04.2f
#10	L_DR_V	Attenuation (losses) between LV-RIP and LV-LCIP (switch attenuation between reference channel at switch plane and common input plane) at specified temperature	dB	4	4 bytes %04.2f
#11	L_DC_V	Attenuation (losses) between LV-CIP and LV-LCIP (switch attenuation between calibration channel at switch plane and common input plane) at specified temperature	dB	4	4 bytes %04.2f
#12	L_R_V	Attenuation (losses) between V-OPR and LV-RIP (input connector) at specified temperature	dB	4	4 bytes %04.2f
#13	L_1_H	Attenuation (losses) between HAP and HAP2 (radiator of the antenna) at specified temperature	dB	4	4 bytes %04.2f

Field #	Tag name	Description	Units	Bytes	Size
#14	L_2_H	Attenuation (losses) between HAP2 and HIP (feed network of the antenna) at specified temperature	dB	4	4 bytes %04.2f
#15	L_NC_H	Attenuation (losses) between HIP and H-OPV (output connector) at specified temperature	dB	4	4 bytes %04.2f
#16	L_A_H	Attenuation (losses) between H-OPV and LH-VIP (input connector) at specified temperature	dB	4	4 bytes %04.2f
#17	L_DA_H	Attenuation (losses) between LH-VIP and LH-LCIP (switch output) at specified temperature	dB	4	4 bytes %04.2f
#18	L_DR_H	Attenuation (losses) between LV-RIP and LV-LCIP (switch attenuation between reference channel at switch plane and common input plane) at specified temperature	dB	4	4 bytes %04.2f
#19	L_DC_H	Attenuation (losses) between LV-CIP and LV-LCIP (switch attenuation between calibration channel at switch plane and common input plane) at specified temperature	dB	4	4 bytes %04.2f
#20	L_R_H	Attenuation (losses) between H-OPR and LH-RIP (input connector) at specified temperature	dB	4	4 bytes %04.2f
#21	C_A_V	Correction to NIR response (in mode A) (See chapter 4.2.1 in [RD.06])	K/K	9	9 bytes %+5.2E+00

Field #	Tag name	Description	Units	Bytes	Size
#22	D_A_V	Correction to NIR response (in mode A) (See chapter 4.2.1 in [RD.06])	K	9	9 bytes %+5.2E+00
#23	U_A_V	Correction to temperature sensitivity (in mode A) (See chapter 4.2.1 in [RD.06])	K/K	9	9 bytes %+5.2E+00
#24	A_V	Temperature sensitivity correction (in mode A) (See chapter 4.2.1 in [RD.06])	K/K	9	9 bytes %+5.2E+00
#25	B_V	Temperature sensitivity correction (in mode A) (See chapter 4.2.1 in [RD.06])	K/K	9	9 bytes %+5.2E+00
#26	C_R_V	Correction to NIR response (in mode R) (See chapter 4.3 in [RD.06])	K/K	9	9 bytes %+5.2E+00
#27	D_R_V	Correction to NIR response (in mode R) (See chapter 4.3 in [RD.06])	K	9	9 bytes %+5.2E+00
#28	U_R_V	Correction to temperature sensitivity (in mode R) (See chapter 4.3 in [RD.06])	K/K	9	9 bytes %+5.2E+00
#29	C_A_H	Correction to NIR response (in mode A) (See chapter 4.2.1 in [RD.06])	K/K	9	9 bytes %+5.2E+00
#30	D_A_H	Correction to NIR response (in mode A) (See chapter 4.2.1 in [RD.06])	K	9	9 bytes %+5.2E+00
#31	U_A_H	Correction to temperature sensitivity (in mode A) (See chapter 4.2.1 in [RD.06])	K/K	9	9 bytes %+5.2E+00
#32	A_H	Temperature sensitivity correction (in mode A) (See chapter 4.2.1 in [RD.06])	K/K	9	9 bytes %+5.2E+00

Field #	Tag name	Description	Units	Bytes	Size
#33	B_H	Temperature sensitivity correction (in mode A) (See chapter 4.2.1 in [RD.06])	K/K	9	9 bytes %+5.2E+00
#34	C_R_H	Correction to NIR response (in mode R) (See chapter 4.3 in [RD.06])	K/K	9	9 bytes %+5.2E+00
#35	D_R_H	Correction to NIR response (in mode R) (See chapter 4.3 in [RD.06])	K	9	9 bytes %+5.2E+00
#36	U_R_H	Correction to temperature sensitivity (in mode R) (See chapter 4.3 in [RD.06])	K/K	9	9 bytes %+5.2E+00
#37	List_of_Dicke_Switch_Values	List containing the Dicke Switch data structures, with "count" field (count=3)	Tag	2	
Dicke_Switch_Values (Repeated "count" times)					
#38	Temperature	Temperature at which the Dicke Switch values were obtained	Tag C	7	%+07.3f
#37	Amplitude_Dicke_Switch_V	Dicke Switch Isolation Module for V polarisation (See chapter 3.5.3 in [RD.06])	dB	5	5 bytes %05.2f
#38	Phase_Dicke_Switch_V	Dicke Switch Isolation Phase for V polarisation (See chapter 3.5.3 in [RD.06])	deg	8	8 bytes %+08.3f
#39	Amplitude_Dicke_Switch_H	Dicke Switch Isolation Module for H polarisation (See chapter 3.5.3 in [RD.06])	dB	5	5 bytes %05.2f
#40	Phase_Dicke_Switch_H	Dicke Switch Isolation Phase for H polarisation (See chapter 3.5.3 in [RD.06])	deg	8	8 bytes %+08.3f

Field #	Tag name	Description	Units	Bytes	Size
		End of Dicke_Switch_Values structure			
		End of NIR_Data structure			
#41	List_of_NIR_Default_Data	List containing the NIR default data structures, with “count” field (count=3)	Tag	2	
		NIR_Default_Data structure (Repeated “count” times)			
#42	NIR_Default_Data	XML structure containing the variables described below	Tag		
#43	NIR_ID	NIR Unique identifier	N/A	1	1 byte Integer formed number of NIR
#44	NIR_Expected_BT_H	NIR-A Expected Brightness Temperature in H polarisation $T'_{A0,h}$	K	12	12 bytes %+012.6f
#45	NIR_Expected_BT_V	NIR-A Expected Brightness Temperature in V polarisation $T'_{A0,v}$	K	12	12 bytes %+012.6f
#46	T_Noise_Cal_H	NIR-A antenna noise injection temperature during calibration $T_{NA0,h}$	K	12	12 bytes %+012.6f
#47	T_Noise_Cal_V	NIR-A antenna noise injection temperature during calibration $T_{NA0,v}$	K	12	12 bytes %+012.6f
#48	NIR_Observed_BT_H	NIR-R observed brightness temperature + injected temperature in H polarization at LH-HIP $T^{CIP}_{A\_ON0,h}$	K	12	12 bytes %+012.6f

Field #	Tag name	Description	Units	Bytes	Size
#49	NIR_Observed_BT_V	NIR-R observed brightness temperature + injected temperature in V polarization at LH-VIP $T^{CIP}_{A\_ON0,v}$	K	12	12 bytes %+012.6f
#50	T_Noise_Cal_Ref_H	NIR-R noise injection temperature in the reference branch during calibration $T_{NR0,h}$	K	12	12 bytes %+012.6f
#51	T_Noise_Cal_Ref_V	NIR-R noise injection temperature in the reference branch during calibration $T_{NR0,v}$	K	12	12 bytes %+012.6f
#52	T_Phys_Tp6	Reference Physical Temperature of the antenna intermediate layer (T_{p6}).	K	12	12 bytes %+012.6f
#53	T_Phys_Tp7	Reference Physical Temperature of the antenna patch (T_{p7}).	K	12	12 bytes %+012.6f
#54	T_Phys_Tp1_H	Reference Physical Temperature of the NIR diode (T_{p1h}).	K	12	12 bytes %+012.6f
#55	T_Phys_Tp1_V	Reference Physical Temperature of the NIR diode (T_{p1v}).	K	12	12 bytes %+012.6f
End of NIR_Default_Data structure					
End of NIR_Characterisation structure					

4.5. PLM Characterisation Table

This file contains all parameters calibrated on-ground referent to elements of the PLM, as well as operational parameters like the intermediate frequency where the instrument is operating.

The elements calibrated on-ground are the reference thermistors provided in each CMN unit, which are calibrated with known temperature sources, and whose output can be measured in-flight for calibration of the other thermistors measurements. The reference temperatures shall also be provided here, as they should remain constant.

Additionally, parameters used in the conversion of ancillary packet into engineering units are also provided in this product. These conversion parameters include Xband telemetry parameters, normalisation ranges for PMS and NIR measurements, and coefficients for the thermistor modelling.

4.5.1. Main Product Header

See 4.1.1.

4.5.2. Specific Product Header

See 4.1.2

4.5.3. Data set

4.5.3.1. PLM_PARAMETERS

This file contains a unique data set that contains the thermistor on-ground calibrated parameters, per each CMN unit. Its contents shall be referred in ASCII XML format. The data set is formed by 1 Data Set Record with all the information.

Table 13: PLM parameters Characterisation Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	PLM_Parameters	Name describing the Data Set. XML structure containing the variables described below	Tag		
#02	Intermediate_Frequency_Nominal	Central frequency of operation in L-band, at which the instrument operates in the nominal correlator layer (1413.5 MHz)	MHz	12	12 bytes %+012.6f
#02b	Intermediate_Frequency_Redundant	Central frequency of operation in L-band, at which the instrument operates in the redundant correlator layer (1413.5 MHz)	MHz	12	12 bytes %+012.6f
#03	Low_Frequency	Lower end of bandwidth frequency in L-band at which the instrument operates (1403.5 MHz)	MHz	12	12 bytes %+012.6f

Field #	Tag name	Description	Units	Bytes	Size
#03b	Local_Oscillator_Frequency	Local Oscillator Frequency, used in the computation of phase parameters in the FWF shape (1396.0 MHz)	MHz	12	12 bytes %+012.6f
#04	Time_Delay_Minus_T	Time delay applied for measuring FWF at –t. Shall be constant and set to -1/55.84MHz.	µs	12	12 bytes %+012.6f
#05	Time_Delay_Plus_T	Time delay applied for measuring FWF at +t. Shall be constant and set to +1/55.84MHz.	µs	12	12 bytes %+012.6f
#05b	DICOS_Sampling	Normalisation value for DICOS correlations. It represents the sampling length of each sample interval Default value is 65438	N/A	5	5 bytes %+05d
#06	NIR_Sampling	Normalisation value for NIR pulse length ancillary measurements. It represents the sampling length of each sample interval Default value is 65535	N/A	5	5 bytes %+05d
#07	LICEF_Directivity_H	Averaged directivity value to be used in radiometric accuracy computation for H polarisation. Default value is 8.5	N/A	8	8 bytes %+08.6f
#07b	LICEF_Directivity_V	Averaged directivity value to be used in radiometric accuracy computation for V polarisation. Default value is 8.5	N/A	8	8 bytes %+08.6f
#08	Xband_Range	Linear conversion range for X-band telemetry voltages used in conversion from 2's complement. Default value is 39.0625mV	mV	8	8bytes %+08.6f

Field #	Tag name	Description	Units	Bytes	Size
#09	Xband_Ref_Temp	Reference temperature for X-band temperature telemetry voltages conversion to Kelvin. Default value is 293K	K	8	8bytes %+08.6f
#10	Xband_Ref_Resist	Reference resistance for X-band temperature telemetry voltages conversion to Kelvin. Default value is 15 KOhm	Ohm	8	8bytes %+08.6f
#11	Xband_Ref_B	Reference B parameter for X-band telemetry voltages used in conversion from 2's complement. Default value is 4150K	K	8	8bytes %+08.6f
List CMN Units (count=12)					
#12	List_of_CMN_Unit	List containing the CMN_Unit data structures, with "count" field (count=12)	Tag	2	
#13	CMN_Unit	XML structure containing the variables described below	Tag		
#14	CMN_ID	Unique ID defining correlator unit to which the parameters are applicable: H1-H3, A1-C3	N/A	2	2 bytes
#15	M_Cal_Nom	Calibration coefficient relating dV/dT for nominal layer thermistors	V/K	8	8 bytes %+08.5f
#16	Q_Cal_Nom	Calibration coefficient relating dV for nominal layer thermistors	V	8	8 bytes %+08.5f
#15b	M_Cal_Red	Calibration coefficient relating dV/dT for redundant layer thermistors	V/K	8	8 bytes %+08.5f

Field #	Tag name	Description	Units	Bytes	Size
#16b	Q_Cal_Red	Calibration coefficient relating dV for redundant layer thermistors	V	8	8 bytes %+08.5f
#17	T_Low	Lowest reference temperature (constant in time)	ºC	9	9 bytes %+09.5f
#18	T_High	Highest reference temperature (constant in time)	ºC	9	9 bytes %+09.5f
#19	G1G2VC	Term in the Resistance computation equation. Default value is –19.68503937007874	V	18	18 bytes %+018.14f
#20	G2VC	Term in the Resistance computation equation. Default value is –15.15748031496063	V	18	18 bytes %+018.14f
#21	R1	Term in the Resistance computation equation. Default value is 3010	Ohm	18	18 bytes %+018.14f
#22	A	Steinhart and Hart equation term characterising the thermistor in the current CMN. Default value is 0.001400531	K^{-1}	12	18 bytes %+011.9f
#23	B	Steinhart and Hart equation term characterising the thermistor in the current CMN. Default value is 0.000237737	K^{-1}	12	18 bytes %+011.9f

Field #	Tag name	Description	Units	Bytes	Size
#24	C	Steinhart and Hart equation term characterising the thermistor in the current CMN. Default value is 0.000000098	K^{-1}	12	18 bytes %+011.9f
#25	PMS_Range	Linear conversion range for PMS voltages used in conversion from 2's complement. Default value is 5V	V	2	2bytes %02d
End of List_of_CMN_Unit structure					
List LICEF Positions (unit=69)					
#26	List_of_LICEF_Position	List containing the LICEF_Position data structures, with "count" field (count=69)	Tag	2	
#27	LICEF_Position	XML structure containing the variables described below	Tag		
#28	LICEF_ID	Unique ID defining LICEF or NIR-LICEF to which the measurements are applicable (from 1 to 69) Format is XXYZZ, where: ❑ XX indicates the arm location (A_, AB, B_, BC, C_ or CA) ❑ Y indicates polarisation for NIR elements (H, V or _) ❑ ZZ indicates LICEF number in arm location (01, 02, 03,… 21) For example AB_03, CAH01, B__18	N/A	5	5 chars
#29	X	X horizontal position of the LICEF on a reference frame centred on the Hub and positive in the direction LICEF NIR BC 03 to LICEF BC 01	mm	8	8 bytes %+08.5f

Field #	Tag name	Description	Units	Bytes	Size
#30	Y	Y vertical position of the LICEF on a reference frame centred on the Hub and positive in the direction of the axis contained between arms A and B	mm	8	8 bytes %+08.5f
#31	Z	Z off-plane position of the LICEF on a reference frame centred on the Hub and positive in the direction formed by the natural normal vector to the XY plane	mm	8	8 bytes %+08.5f
End of List_of_LICEF_Position structure					

4.6. S-parameters of MIRAS

For calibration purposes, all S-parameters of the connections inside MIRAS shall be measured by the manufacturer of MIRAS in its full implementation, and provided as an initial auxiliary file.

The Scattering Parameters from the noise source to the j and k receivers relevant at this stage are:

- Transfer parameters S_{jk} and S_{kj}, a measure of the complex insertion gain;
- Driving point parameters S_{jj} and S_{kk}, a measure of the input and output mismatch loss

All parameters will be used in the change of reference planes for all electronic components, mainly, in the computation of System Temperatures and calibration coefficients.

Auxiliary data required is the S-parameters of the Noise Distribution Network and the S-parameters of the switch for every LICEF receiver.

S-parameters shall be provided separately for each component of the NDN. Each power divider, noise source and connecting cables shall be characterised against physical temperature and presented in this file.

4.6.1. Main Product Header

See 4.1.1.

4.6.2. Specific Product Header

See 4.1.2

4.6.3. Data set

This file is formed by two data sets that contain the characterisation of the CAS and Switch S-parameters. Each data set is formed by 1 Data Set Record with all the information.

4.6.3.1. NDN_S_PARAMETERS

This data set contains the S-parameters for the NDN, in the hub and all arm sections. Its contents shall be referred in ASCII XML format. This data set is formed by 1 Data Set Record with all the information.

Table 14: NDN S-parameters Characterisation Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	NDN_S_Parameters	Name describing the Data Set. XML structure containing the variables described below	Tag		
Hub_NS					
#02	Hub_NS	XML structure containing the variables described below	Tag		
#03	Hub_ID	Unique ID defining Noise Source unit to which the parameters are applicable: NS_H	N/A	4	4 bytes
#04	List_of_Values	List containing the S-parameters data structures, with "count" field (count=5)	Tag	2	
Values (Repeated "count" times)					
#05	Temperature	Temperature at which the S-parameters were obtained	Tag C	7	%+07.3f
#06	S_jk_Magnitude (where j and k range from 1 to 5)	S parameter relating connection between the 5 port networks in the hub Noise Source. Forms a matrix of 5x5 values defining amplitude	linear ~~dB~~	11	%+011.8f
#07	S_kj_Phase (where j and k range from 1 to 5)	S parameter relating connection between the 5 port networks in the hub Noise Source. Forms a matrix of 5x5 values defining phase	deg	10	%+010.5f
End of Hub_NS structure					
Arms Noise Sources (repeated per arm section)					

Field #	Tag name	Description	Units	Bytes	Size
#08	List_of_Arm_NS	List containing the Arm_NS data structures, with "count" field. Count is always 9.	Tag	2	
#09	Arm_NS	XML structure containing the variables described below	Tag		
#10	Arm_ID	Unique ID defining Noise Source unit to which the parameters are applicable: NS_A1, NS_A2, NS_A3, NS_B1, NS_B2, NS_B3, NS_C1, NS_C2, NS_C3	N/A	5	5 bytes
#11	List_of_Values	List containing the S-parameters data structures, with "count" field (count=5)	Tag	2	
Values (Repeated "count" times)					
#12	Temperature	Temperature at which the S-parameters were obtained	Tag C	7	%+07.3f
#13	S_jk_Magnitude (where j and k range from 1 to 4)	S parameter relating connection between the 4 port networks in each of the arms Noise Sources. Forms a matrix of 4x4 values defining amplitude	linear ~~dB~~	11	%+011.8f
#14	S_kj_Phase (where j and k range from 1 to 4)	S parameter relating connection between the 4 port networks in each of the arms Noise Sources. Forms a matrix of 4x4 values defining phase	deg	10	%+010.5f
End of List_of_Arm_NS structure					
Power Dividers (repeated per unit)					
#15	List_of_Power_Divider	List containing the Power_Divider data structures, with "count" field. Count is always 12.	Tag	2	

Field #	Tag name	Description	Units	Bytes	Size
#16	Power_Divider	XML structure containing the variables described below	Tag		
#17	Power_Divider_ID	Unique ID defining Power Divider unit to which the parameters are applicable: PD_H1, PD_H2, PD_H3, PD_A1, PD_A2, PD_A3, PD_B1, PD_B2, PD_B3, PD_C1, PD_C2, PD_C3	N/A	5	5 bytes
#18	List_of_Values	List containing the S-parameters data structures, with "count" field (count=5)	Tag	2	
Values (Repeated "count" times)					
#19	Temperature	Temperature at which the S-parameters were obtained	Tag C	7	%+07.3f
#20	S_jk_Magnitude (where j and k range from 1 to 8)	S parameter relating connection between the 8 port networks in each of the Power Dividers. Forms a matrix of 8x8 values defining amplitude	linear ~~dB~~	11	%+011.8f
#21	S_kj_Phase (where j and k range from 1 to 8)	S parameter relating connection between the 8 port networks in each of the Power Dividers. Forms a matrix of 8x8 values defining phase	deg	10	%+010.5f
End of List_of_Power_Divider structure					
Cables (repeated per unit)					
#22	List_of_Cable	List containing the Cable data structures, with "count" field. Count is always 96.	Tag	2	
#23	Cable	XML structure containing the variables described below	Tag		
#24	Cable_ID	Unique ID defining Cable unit to which the parameters are applicable.	N/A	6	6 bytes

Field #	Tag name	Description	Units	Bytes	Size
		There are 8 cables per arm or hub section, naming convention is C_"*section_name*"_"*cable_number*": Where *section_name* can be H1, H2, H3, A1, A2, A3, B1, B2, B3, C1, C2 or C3, and *cable_number* goes from 1 to 8. (e.g. C_C1_3)			
#25	List_of_Values	List containing the S-parameters data structures, with "count" field (count=10)	Tag	2	
Values (Repeated "count" times)					
#26	Temperature	Temperature at which the S-parameters were obtained	Tag C	7	%+07.3f
#27	S_jk_Magnitude (where j and k range from 1 to 2)	S parameter relating connection between the 2 port networks in each of the cables. Forms a matrix of 2x2 values defining amplitude	linear ~~dB~~	11	%+011.8f
#28	S_kj_Phase (where j and k range from 1 to 2)	S parameter relating connection between the 2 port networks in each of the cables. Forms a matrix of 2x2 values defining phase	deg	10	%+010.5f
End of List_of_Cable structure					

4.6.3.2. SWITCH_S_PARAMETERS

This data set contains the S-parameters for the switches, in all receivers in all sections. Its contents shall be referred in ASCII XML format. Each data set is formed by 1 Data Set Record with all the information.

Table 15: Switch S-parameters Characterisation Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					

Field #	Tag name	Description	Units	Bytes	Size
#01	Switch_ S_Parameters	Name describing the Data Set. XML structure containing the variables described below	Tag		
#02	List_of_Switch	List containing the Switch data structures, with "count" field (count=72)	Tag	2	
		Switch (Repeated "count" times)			
#03	Switch_ID	Unique ID defining LICEF or NIR-LICEF to which the measurements are applicable (from 1 to 69) Format is XXYZZ, where: ❑ XX indicates the arm location (A_, AB, B_, BC, C_ or CA) ❑ Y indicates polarisation for NIR elements (H, V or _) ❑ ZZ indicates LICEF number in arm location (01, 02, 03,… 21) For example AB_03, CAH01, B__18	N/A	5	5 chars
#04	List_of_Values	List containing the Switch S-parameters data structures, with "count" field (count=10)	Tag	2	
		Values (Repeated "count" times)			
#05	Temperature	Temperature at which the S-parameters were measured	K	6	6 bytes %06.2f
#06	S_LH	S parameter relating connection between the antenna H-pol Input plane and TRF Output plane normalized with the S parameter relating connection between the Calibration Input plane and TRF Output plane	linear ~~dB~~, deg	16	16 bytes complex value

Field #	Tag name	Description	Units	Bytes	Size
#07	S_LV	S parameter relating connection between the antenna V-pol Input plane and TRF Output plane normalized with the S parameter relating connection between the Calibration Input plane and TRF Output plane	linear ~~dB~~, deg	16	16 bytes complex value
#08	S_LC	S parameter relating connection between the Calibration Input plane and TRF Output plane normalized with the S parameter relating connection between the Calibration Input plane and TRF Output plane The switch in U position is not measured. Losses between CIP and U are assumed negligible, so it is assumed to be 1.	linear ~~dB~~, deg	16	16 bytes complex value
#09	S_LU	S parameter relating connection between the Unoise Input plane and TRF Output plane. The switch in U position is not measured. Losses between CIP and U are assumed negligible, so this value is assumed to be 1.	linear, deg	16	16 bytes complex value
End of List_of_Values structure					
End of List_of_Swicth structure					

4.7. Receivers characterisation (ohmic efficiency and absolute phase)

The Ohmic loss is the power dissipation from resistance, and the most relevant parameter is the Antenna Ohmic Efficiency (η), being the ratio of the total radiated power divided by the total power accepted by the antenna.

It is also equivalent to the ratio of the antenna radiation resistance (R_{rad}) divided by the sum of the antenna radiation resistance and the antenna ohmic losses resistance (R_{Ω}).

The value η shall be provided by the MIRAS manufacturer in its full implementation in an auxiliary file, and may be subjected to validation in orbit, but not calibration.

Antenna ohmic efficiency shall be presented as a mean value and standard deviation for every LICEF and polarisation value.

The receivers' pattern absolute phase is required to translate the phase of calibrated visibilities from the input planes to the antenna planes. They shall be measured during IVT at ESTEC and assumed invariant to physical temperature.

4.7.1. Main Product Header

See 4.1.1.

4.7.2. Specific Product Header

See 4.1.2

4.7.3. Data set

This file contains a unique data set that contains the efficiency and phase parameters for all LICEF receivers, in the hub and all arm sections. Its contents shall be referred in ASCII XML format. This data set is formed by 1 Data Set Record with all the information.

Table 16: Antenna Characterisation Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	LICEF_Characterisation	Name describing the Data Set. XML structure containing the variables described below	Tag		
#02	List_of_LICEF_Data	List containing the LICEF_Data data structures, with "count" field (count=72)	Tag	2	
LICEF_Data (Repeated "count" times)					
#03	LICEF_ID	Unique ID defining LICEF or NIR-LICEF to which the measurements are applicable (from 1 to 69) Format is XXYZZ, where: ❑ XX indicates the arm location (A_, AB, B_, BC, C_ or CA) ❑ Y indicates polarisation for NIR elements (H, V or _)	N/A	5	5 chars

Field #	Tag name	Description	Units	Bytes	Size
		❑ ZZ indicates LICEF number in arm location (01, 02, 03,… 21) For example AB_03, CAH01, B__18			
#04	List_of_Efficiency_Data	List containing the Efficiency_Data data structures, with "count" field (count=2)	Tag	2	
Efficiency_Data structure (repeated per polarisation)					
#05	Polarisation	H or V polarisation value where the Efficiency was measured	N/A	1	1 byte integer
#06	Mean_Efficiency	Mean ohmic efficiency value for LICEF and polarisation	N/A	8	8 bytes float value each
#07	STD_Efficiency	Standard deviation of ohmic efficiency value for LICEF and polarisation	N/A	8	8 bytes float value each
End of List_of_Efficiency_Data structure					
#08	List_of_Abs_Phase_Data	List containing the Abs_Phase_Data data structures, with "count" field (count=2)	Tag	2	
Abs_Phase_Data structure (repeated per polarisation)					
#09	Polarisation	H or V polarisation value where the Absolute Phase was measured	N/A	1	1 byte integer
#10	Mean_Abs_Phase	Mean absolute antenna pattern phase value for LICEF and polarisation	deg	8	8 bytes float value each
#11	Std_Abs_Phase	Standard deviation of absolute antenna pattern phase value for LICEF and polarisation	deg	8	8 bytes float value each
End of List_of_Abs_Phase_Data structure					

Field #	Tag name	Description	Units	Bytes	Size
		End of List_of_LICEF_Data structure			

4.8. Normalised amplitude and phase patterns of all antennas

As seen in [RD.02], one of the things that should be taken in consideration in the process of inversion is that not all antennas have the same radiation pattern. These differences affect the amplitude and the phase of the antenna voltage patterns. For each antenna k, these patterns can be expressed by the following function:

$$F_{nk}(\xi,\eta) = F_n(\xi,\eta)\left[1+\Delta F_{nk}(\xi,\eta)\right]e^{j\Delta\phi_{nk}(\xi,\eta)} \quad \textbf{Eq. 1}$$

Where $F_n(\xi,\eta)$ is the average radiation voltage pattern of all antennas, $\Delta F_{nk}(\xi,\eta)$ and $\Delta\phi_{nk}(\xi,\eta)$ are the voltage amplitude and phase dispersions.

The error induced in the visibility sample (u_{kl}, v_{kl}) by the antenna voltage patterns is proportional to the antenna temperature and the sample (u_{kl}, v_{kl}) of the Fourier transform of the antenna pattern cross-error.

The normalized power pattern Pn, gives the relative response to signals from different directions and has its maximum value on the boresight direction. Due to this normalization, the normalized power pattern will not be affected by ohmic loss. It will certainly be quite unaffected by loss in the single mode transmission line as this cannot affect the form of the aperture plane illumination or the power pattern.

Although subjected to fluctuations, it can be assumed that the loss will result in a uniform reduction of the magnitude of the aperture plane electric field, by a factor equal to the square root of the fractional power reduction.

Directivity is the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions.

The average radiation intensity is equal to the total power radiated by the antenna divided by 4π. If the direction is not specified, the direction of maximum radiation is implied.

All the parameters considered in this section should be measured and provided once by the MIRAS manufacturer. These parameters will not be subjected to further calibration during satellite operation; at most they shall be validated.

4.8.1. Main Product Header

See 4.1.1.

4.8.2. Specific Product Header

See 4.1.2

4.8.3. Data set

This data set contains the antenna patterns for all LICEF and NIR-LICEF, expressed in amplitude and phase as measured during the on-ground characterisation. Co-polar and cross-polar patterns shall be presented for each polarisation (H and V). Its contents shall be in binary format. There shall be a single file per LICEF, using the last two underscore characters of the filename as a counter for the LICEF number.

Each file shall contain a unique data set with the amplitude and phase measurements. This data set shall be comprised of 4 Data Set Records, one per each type of polarisation as described in field #2.

Table 17: Antenna Patterns Characterisation Data Set

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	Antenna_Pattern	Name describing the Data Set. Binary structure containing the variables described below	Tag		
Data Set Record (repeated per MEASUREMENT value)					
#02	Measurement	Enumerated value for Horizontal co-polar and cross-polar, or Vertical polarisation co-polar and cross-polar. (X_COPL='1', X_CRPL='2', Y_COPL='3', Y_CRPL='4').	N/A	1	1 byte char
#03	Frequency_Low	Lowest frequency value at which the pattern was measured (1404MHz)	MHz	8	8 bytes double
#04	Frequency_Centre	Centre frequency value at which the pattern was measured (1413MHz)	MHz	8	8 bytes double
#05	Frequency_High	Highest frequency value at which the pattern was measured (1423MHz)	MHz	8	8 bytes double
#06	Pattern_Low_Amplitude	Antenna pattern amplitude in linear units, measured in known points of the cosines domain plane at the lowest frequency (Minimum sampling space to be 181x181, the more samples the better)	linear	8	8 bytes double value each

Field #	Tag name	Description	Units	Bytes	Size
#07	Pattern_Low_Phase	Antenna pattern phase in known points of the cosines domain plane measured at the lowest frequency (Minimum sampling space to be 181x181, the more samples the better)	deg	8	8 bytes double value each
#08	Pattern_Centre_Amplitude	Antenna pattern amplitude in linear units, measured in known points of the cosines domain plane at the centre frequency (Minimum sampling space to be on 181x181, the more samples the better)	linear	8	8 bytes double value each
#09	Pattern_Centre_Phase	Antenna pattern phase in known points of the cosines domain plane measured at the centre frequency (Minimum sampling space to be on 181x181, the more samples the better)	deg	8	8 bytes double value each
#10	Pattern_High_Amplitude	Antenna pattern amplitude in linear units, measured in known points of the cosines domain plane at the highest frequency (Minimum sampling space to be 181x181, the more samples the better)	linear	8	8 bytes double value each
#11	Pattern_High_Phase	Antenna pattern phase in known points of the cosines domain plane measured at the highest frequency (Minimum sampling space to be 181x181, the more samples the better)	deg	8	8 bytes double value each

Additionally, one more auxiliary file shall contain the cosines domain equivalent coordinates where the antenna patterns have been measured. These coordinates are obtained projecting the spherical coordinates obtained during the measurement campaign into the cosines domain plane. A typical sampling size shall be a 1° resolution, which will influence the size of the patterns presented above.

Table 18: Antenna Pattern Coordinates Data Set

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	Antenna_Pattern_Coordinates	Name describing the Data Set. XML structure containing the variables described below	Tag		
#02	XI_Value	Coordinate value in the Xi axis	N/A	8	8 bytes %+08.5f
#03	ETA_Value	Coordinate value in the Eta axis	N/A	8	8 bytes %+08.5f

4.9. Averaged Antenna Pattern

During L1 Processing, it is needed at certain stages to use the average of the antenna patterns presented in the previous section, in order to use an approximation of the gain in certain viewing directions.

In order to avoid a computation of this average in runtime, the following ADF is proposed, containing the averaged antenna pattern of the instrument, in both polarisations, for co-polar and cross-polar terms, and also for the front and back patterns. The filename type of this ADF shall be the same as the ones for the antenna pattern, but using the numeric identifier #99.

4.9.1. Main Product Header

See 4.1.1.

4.9.2. Specific Product Header

See 4.1.2

4.9.3. Data set

This data set contains the averaged antenna patterns for all LICEF and NIR-LICEF, expressed in amplitude and phase as measured during the on-ground characterisation. Co-polar and cross-polar patterns shall be presented for each polarisation (H and V). Its contents shall be in binary format.

This file shall contain a unique data set with the amplitude and phase measurements. This data set shall be comprised of 8 Data Set Records, one per each type of polarisation as described in field #2.

Table 19: Averaged Antenna Pattern Characterisation Data Set

Field #	Tag name	Description	Units	Bytes	Size
Definition					

Field #	Tag name	Description	Units	Bytes	Size
#01	Averaged_Antenna_Pattern	Name describing the Data Set. Binary structure containing the variables described below	Tag		
Data Set Record (repeated per MEASUREMENT value)					
#02	Measurement	Enumerated value for Horizontal co-polar and cross-polar, or Vertical polarisation co-polar and cross-polar, and front or back patterns. (X_COPL='1', X_CRPL='2', Y_COPL='3', Y_CRPL='4', X_COPL_BACK='5', X_CRPL_BACK='6', Y_COPL_BACK='7', Y_CRPL_BACK='8').	N/A	1	1 byte char
#03	Pattern_Amplitude	Antenna pattern amplitude in linear units, averaged in known points of the cosines domain plane at the centre frequency (Minimum sampling space to be on 181x181, the more samples the better)	linear	8	8 bytes double value each
#04	Pattern_Phase	Antenna pattern phase averaged in known points of the cosines domain plane at the centre frequency (Minimum sampling space to be on 181x181, the more samples the better)	deg	8	8 bytes double value each

4.10. Failing Components

Parameters defined in this auxiliary file shall have precedence over any status inferred from telemetry measurements. In this way, if it was decided to eliminate the contribution of some LICEF due to known failures, it shall be set in this file.

Failing components may vary from single LICEF, to correlator units and LICEF-NIR capabilities.

4.10.1. Main Product Header

See 4.1.1.

4.10.2. Specific Product Header

See 4.1.2

4.10.3. Data set

This file contains a unique data set that contains the failure status for all LICEF receivers, in the hub and all arm sections, correlator units and NIR units. Its contents shall be referred in ASCII XML format. The data set is formed by 1 Data Set Record with all the information.

Failures shall be presented in four separate lists:

- per LICEF ID: meaning that correlations with that LICEF shall be disregarded
- per CMN ID: meaning that correlations performed with the LICEF under that CMN shall be disregarded
- per NIR ID: meaning that BT measurements made with that NIR shall be disregarded (correlations with LICEF-NIR are contemplated in first point)
- per PMS ID: meaning that System Temperature measurements made with that PMS shall be disregarded (correlations de-normalisation shall be affected)

Table 20: Failing components Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	Failing_Components	Name describing the Data Set. XML structure containing the variables described below	Tag		
LICEF Data (Repeated per LICEF_ID)					
#02	LICEF_ID	Unique ID defining LICEF or NIR-LICEF to which the measurements are applicable (from 1 to 72 considering that the LICEF_NIR are composed by two LICEF) Format is XXYZZ, where: ❑ XX indicates the arm location (A_, AB, B_, BC, C_ or CA) ❑ Y indicates polarisation for NIR elements (H, V or _) ❑ ZZ indicates LICEF number in arm	N/A	5	5 chars

Field #	Tag name	Description	Units	Bytes	Size
		location (01, 02, 03,… 21) For example AB_03, CAH01, B__18			
Status Data					
#03	H_Failure	If set to TRUE, the signal provided by the LICEF in H polarisation is incorrect. To be taken into account with correlations performed with this LICEF.	N/A	1	1 byte integer
#04	V_Failure	If set to TRUE, the signal provided by the LICEF in V polarisation is incorrect. To be taken into account with correlations performed with this LICEF.	N/A	1	1 byte integer
End of LICEF_Data structure					
Correlator Data (Repeated per CMN_ID)					
#05	CMN_ID	Unique ID defining correlator unit to which the failures are applicable. Valid values are: H1, H2, H3, A1, A2, A3, B1, B2, B3, C1, C2, C3	N/A	2	2 chars
Status Data					
#06	Failure	Correlations performed for those receivers contained within the CMN shall be ignored if set to TRUE	N/A	1	1 byte integer
List Thermistor Data (for each CMN_ID) 16 elements					
#07	Thermistor_ID	Unique ID defining the thermistor unit to which the failures are applicable (TH01 to TH14, RE01 and RE02).	N/A	4	4 bytes
#08	Failure	Physical temperature measurements performed with this thermistor shall be disregarded if set to TRUE	N/A	1	1 byte integer

Field #	Tag name	Description	Units	Bytes	Size
End of CMN_Data structure					
NIR Data (Repeated per NIR_ID)					
#07	NIR_ID	Unique ID defining NIR unit to which the failures are applicable. Valid values are AB, BC and CA	N/A	2	2 chars
Status Data					
#08	H_Failure	Brightness temperature measurements in H polarisation performed for the current NIR shall be ignored if set to TRUE	N/A	1	1 byte integer
#09	V_Failure	Brightness temperature measurements in V polarisation performed for the current NIR shall be ignored if set to TRUE	N/A	1	1 byte integer
End of NIR_Data structure					
PMS Data (Repeated per PMS_ID)					
#10	PMS_ID	Unique ID defining PMS to which the measurements are applicable (from 1 to 72) Format is XXYZZ, where: ❑ XX indicates the arm location (A_, AB, B_, BC, C_ or CA) ❑ Y indicates polarisation for NIR elements (H, V or _) ❑ ZZ indicates LICEF number in arm location (01, 02, 03,… 21) For example AB_03, CAH01, B__18	N/A	5	5 chars
Status Data					
#11	Failure	System Temperatures computed with this PMS shall be discarded if set to	N/A	1	1 byte integer

Field #	Tag name	Description	Units	Bytes	Size
		TRUE			
End of PMS_Data structure					

4.11. Baseline Weights

Parameters defined in this auxiliary file shall be used to establish a weight vector to be multiplied element by element with the calibrated visibilities, prior to the Image Reconstruction process (i.e. multiplication with J+ matrix).

With this file it shall be possible to eliminate the contribution from individual baselines (e.g. across hinges) or influence the averaging method inherent to the Image Reconstruction process..

4.11.1. Main Product Header

See 4.1.1.

4.11.2. Specific Product Header

See 4.1.2

4.11.3. Data set

This file contains a unique data set that contains the weights for all 2556 baselines. Its contents shall be referred in ASCII XML format. The data set is formed by 1 Data Set Record with all the information.

Table 21: Baseline Weights Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	Baseline_Weights	Name describing the Data Set. XML structure containing the variables described below	Tag		
#02	List_of_Baseline_Data	List containing the Baseline data structures, with "count" field (count=2556)	Tag	4	
Baseline_Data					
#03	Baseline_ID	Unique ID defining the baseline to which the measurements are applicable Format is XX_YYxZZ_WW, where: ❑ XX and ZZ indicate the arm	N/A	11	11 chars

Field #	Tag name	Description	Units	Bytes	Size
		location (A_, AB, B_, BC, C_ or CA) ❑ ZZ and WW indicate LICEF number in arm location (01, 02, 03,… 21) For example AB_03xCAH01, B__18xC__05			
#04	Weight	Decimal weight to be applied to each baseline. Default value should be 1 for all baselines.	N/A	5	%05.3d
End of List_of_Baseline_Data structure					

4.12. Best Fit Plane

The Best Fit Plane describes the ideal antenna plane over which the visibilities are assumed to have been measured. Any deviation of the antenna positions from it translates into an error in the visibilities. The Best Fit Plane is the plane that best describes, in a least-square sense, the estimated position of the antenna phase geometrical centres. The information from the Best Fit Plane shall be used as an addition to the nominal attitude to obtain the real instrument attitude, needed to project onto the Earth surface with the minimum geolocation error the image reconstructed in the antenna plane. This auxiliary file shall take precedence over any instrument-pointing attitude for geolocation purposes.

The Best Fit Plane shall be described by the Euler angles (in sequence 321) from the Antenna Plane pointing direction.

There shall also be a placeholder for future updates of the BFP, which may be calibrated in-orbit by matching known coastlines and pointing accuracy.

4.12.1. Main Product Header

See 4.1.1.

4.12.2. Specific Product Header

See 4.1.2

4.12.3. Data set

This file contains a unique data set that contains the Euler angles that define the Best Fit Plane, expressed in the Antenna Plane reference frame. Its contents shall be referred in ASCII XML format. The data set is formed by 2 Data Set Record with all the information, one with the BFP measured on-ground, and another with the deviations of the BFP to be measured in-orbit.

Table 22: Best-Fit Plane Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
#01	Best_Fit_Plane	Name describing the First Data Set. XML structure containing the variables described below	Tag		
#02	Yaw_Angle	Angle to be rotated centred on Z axis of Antenna Plane (pointing direction)	deg	10	%+010.5f
#03	Pitch_Angle	Angle to be rotated centred on Y axis	deg	10	%+010.5f
#04	Roll_Angle	Angle to be rotated centred on X axis	deg	10	%+010.5f
#05	Best_Fit_Plane	XML Closing tag	Tag		
#06	Best_Fit_Plane_Calibration	Name describing the Second Data Set. XML structure containing the variables described below	Tag		
#07	Yaw_Angle	Angle to be rotated centred on Z axis of Best Fit Plane (pointing direction)	deg	10	%+010.5f
#08	Pitch_Angle	Angle to be rotated centred on Y axis	deg	10	%+010.5f
#09	Roll_Angle	Angle to be rotated centred on X axis	deg	10	%+010.5f
#10	Best_Fit_Plane_Calibration	XML Closing tag	Tag		

4.13. Mispointing Angles

The current ADF describes the mispointing angles between the Body Frame referenced in the Proteus quaternions and the Antenna Plane defined by the MIRAS instrument. The information from the mispointing shall be used as an addition to the Best Fit Plane and nominal attitude to obtain the real instrument attitude, needed to project onto the Earth surface with the minimum geolocation error the image reconstructed in the antenna plane.

The mispointing shall be described by the Euler angles (in sequence 321) from the nominal Body Frame instrument pointing direction. There shall be three rotation matrix (i.e. their equivalent euler angles) contained in this ADF.

The first rotation matrix shall cover the change of reference between Proteus quaternion axes, and the S/C axes. In short, it shall handle the axes conversion that is needed from Proteus reference to EE-CFI reference.

The second rotation matrix shall cover the rotation matrix measured on-ground between the S/C axes and the Antenna plane.

Finally, the last rotation matrix shall handle any possible future calibration (in-orbit or on-ground) which may measure mispointing errors in the transformation from Proteus to Antenna frame.

4.13.1. Main Product Header

See 4.1.1.

4.13.2. Specific Product Header

See 4.1.2

4.13.3. Data set

This file contains a unique data set that contains the Euler angles that define the instrument mispointing, expressed in the instrument reference frame. Its contents shall be referred in ASCII XML format. The data set is formed by 3 Data Set Record with all the information.

Table 23: Mispointing Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
#01	Proteus_To_Body	Name describing the First Data Set. XML structure containing the variables described below	Tag		
#02	Yaw_Angle	Angle to be rotated centred on Z axis of Proteus Frame (pointing direction)	deg	10	%+010.5f
#03	Pitch_Angle	Angle to be rotated centred on Y axis	deg	10	%+010.5f
#04	Roll_Angle	Angle to be rotated centred on X axis	deg	10	%+010.5f
#05	Proteus_To_Body	XML Closing tag	Tag		
#06	Body_To_Antenna	Name describing the Second Data Set. XML structure containing the variables described below	Tag		
#07	Yaw_Angle	Angle to be rotated centred on Z axis of Body Frame (pointing direction)	deg	10	%+010.5f
#08	Pitch_Angle	Angle to be rotated centred on Y axis	deg	10	%+010.5f

Field #	Tag name	Description	Units	Bytes	Size
#09	Roll_Angle	Angle to be rotated centred on X axis	deg	10	%+010.5f
#10	Body_To_Antenna	XML Closing tag	Tag		
#11	Mispointing_Calibration	Name describing the Third Data Set. XML structure containing the variables described below	Tag		
#12	Yaw_Angle	Angle to be rotated centred on Z axis of Body Frame (pointing direction)	deg	10	%+010.5f
#13	Pitch_Angle	Angle to be rotated centred on Y axis	deg	10	%+010.5f
#14	Roll_Angle	Angle to be rotated centred on X axis	deg	10	%+010.5f
#15	Mispointing_Calibration	XML Closing tag	Tag		

4.14. Discrete Global Grid

ISEA aperture 4, resolution 9 global hexagonal grid in ASCII format, containing a unique binary counter for each grid point centre, along with its latitude and longitude coordinates.

A specific ordering shall be made of all discrete points into sub-zones, such that access to selected lat-lon coordinates does not imply reading the whole file.

4.14.1. Main Product Header

See 4.1.1.

4.14.2. Specific Product Header

See 4.1.2

4.14.3. Data set

This file contains a unique data set that contains the Fixed Earth Grid coordinates of the ISEA 4-9 hexagonal grid centres. Each point shall be identified by a unique counter, which is the parameter used for referencing the points in the L1c products. Its contents shall be in binary format, not yet defined at the moment if there shall be a special ordering to enable some API quick access and search functions.

The data set is formed by 10 Data Set Records, each one containing a list of points within a zone. These zones are used to allow a fast indexing of the data for search algorithms. They come from the natural decomposition of the icosahedron used in the ISEA projection.

All Data Set Records shall contain the same number of points inside, even if some of them are dummy. This will prevent having variable sized records within the product.

Table 24: ISEA DGG Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	DGG_Grid	Name describing the Data Set. XML structure containing the variables described below	Tag		
Sub-division in Zones					
#02	Zone_ID	Unique ID defining the zone where the points are contained. An initial approach has 10 zones formed by two adjacent triangles of the main ISEA decomposition.	N/A	8	8 bytes integer value
#03	Num_Points	Number of points contained within the zone (if not used, refer to whole file). To avoid variable size records, the number of points in all zones shall be the same, even if it means that some of them will be dummy.	N/A	4	4 bytes integer value (for ISEA 4-9, maximum of 2.7M pixels)
Grid Point Data (repeated NUM_POINTS times)					
#04	Grid_Point _ID	Unique identifier for Earth fixed grid point.	N/A	4	4 bytes (for ISEA 4-9, maximum of 2.7M pixels)
#05	Longitude	Longitude value of grid point over the ellipsoid. Positive west of Greenwich meridian. Range [-180, 180]	10^{-3} deg	4	4 bytes signed integer
#06	Latitude	Latitude value of grid point over the ellipsoid. Positive above equator (North) Range [-90, 90]	10^{-3} deg	4	4 bytes signed integer

Field #	Tag name	Description	Units	Bytes	Size
#07	Altitude	Local altitude of grid point taken from GETASSE30. (http://www.brockmann-consult.de/beam/doc/help/visat/GETASSE30ElevationModel.html)Range goes from [-407, 8752] m	mm	4	4 bytes signed integer

4.15. Land/Sea Mask

Due to the much different requirements for Soil Moisture and Ocean Salinity not only different apodisation windows are needed to separately process the two products, but also a land-sea mask to differentiate the areas of the globe to be processed with each one of them.

This Land/Sea Mask ADF shall be a static file, from which the L1c Pixel Mask ADF will be extracted initially. The purpose of the Land/Sea Mask ADF is to contain the different flags and water content percentage of the DGG pixels, as a fixed reference never to be changed. It shall not be used in the L1 Processors.

The auxiliary data shall be extracted from the USGS Land-Sea mask (10/05/96). In this file, each cell is assigned to either land, water or interrupted area based on the dominant area of a cell, according to the following nomenclature:

- 0=Land
- 1=Water
- 2=Interrupted area (meaning black zones in Fig.3)

Its contents and projection type are shown in the following image:

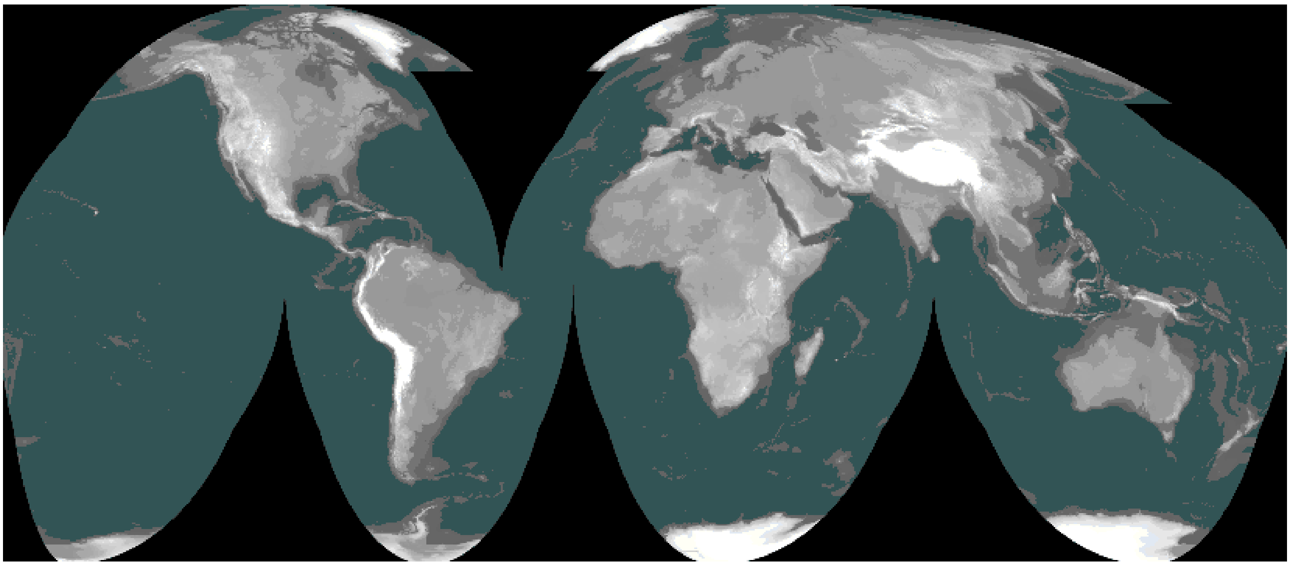

Figure 3: USGS Land-Sea mask

The USGS Land/Sea mask is a Binary Data Set representing a 1-km grid cell in an 8-bit raster image in the interrupted Goodes homolosine map projection. The image, as shown above, is comprised of 17347 lines by 40031 samples with 662Mb in size.

The Interrupted Goode Homolosine projection, developed by J.P. Goode in 1923, is an equal-area pseudo-cylindrical composite map projection which is interrupted to reduce distortion in the major land masses. This projection merges the Mollweide projection for higher latitudes (also called the Homolographic projection) and the Sinusoidal projection for lower latitudes (Goode 1925). The two projections join at 40 44'11.8" North and South; this is where the linear scale of the two projections match. All the major continents, with the exception of Antarctica, are intact. The projection is often presented with repeated sections so that Greenland and the eastern tip of Siberia are not interrupted.

There are C libraries available in order to search for the line and sample in the projection corresponding to a given latitude and longitude. Within each sample, the value for Land or Water can be obtained immediately. The ISEA grid proposed in the previous section has been used to perform a binning of the USGS land/sea mask, in order to compute the water fraction of each ISEA cell. The result has been used to define the flags presented below.

Additionally, the coastline map used in MERIS processing (MERIS uncertainty map for Envisat) and the SW associated to its handling was provided by Brockmann Consult, in order to compute the sea pixels beyond the expanded coastlines (40, 100 and 200km).

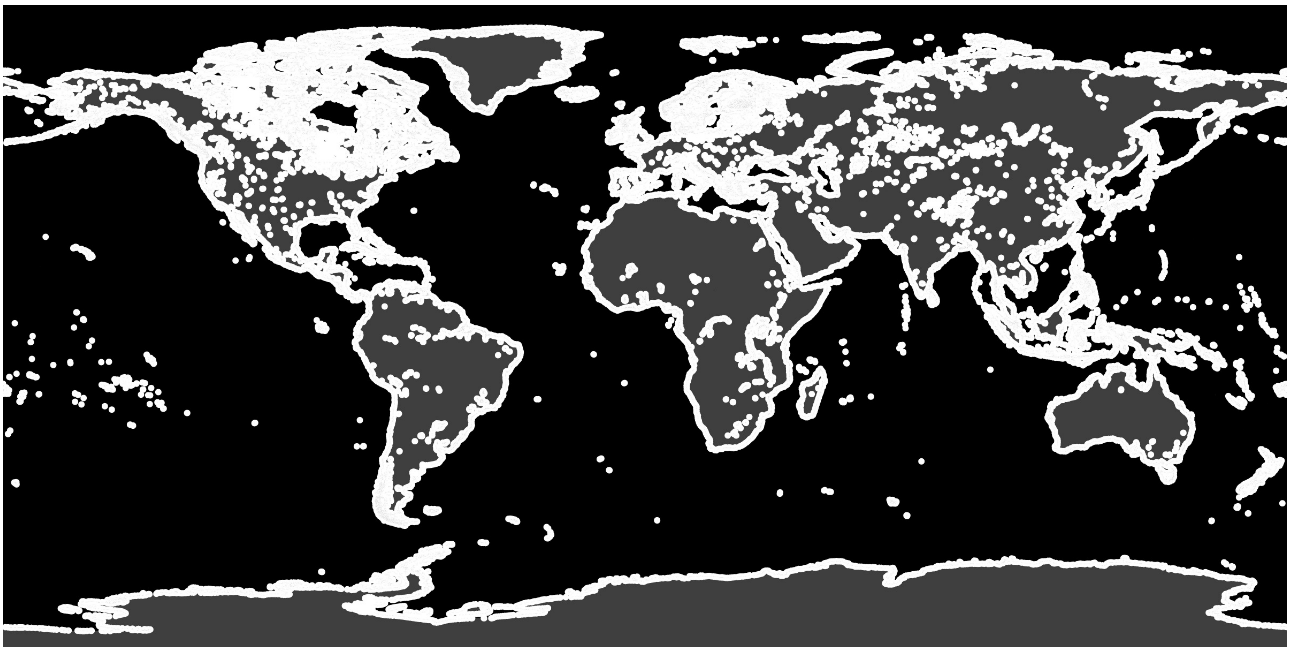

Figure 4: MERIS Uncertainty map for 100km

4.15.1. Main Product Header

See 4.1.1.

4.15.2. Specific Product Header

See 4.1.2

4.15.3. Data set

The USGS data shall be combined with the ISEA Discrete Global Grid presented before, in order to assign to each pixel in that grid a flag marking it as belonging to either category. The only categories that will be available now will be land or sea.

This file contains a unique data set with the pixel information. In the same approach as in the DGG, the data set shall be formed by 10 Data Set Records.

A default pixel water content percentage is also computed by taking into account the shape of the ISEA pixels and the number of land/sea pixels from USGS that fall inside each cell.

Table 25: Land Sea Mask Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
		Definition			
#01	Land_Sea_Mask	Name describing the Data Set. XML structure containing the variables described below	Tag		
		Sub-division in Zones			
#02	Zone_ID	Unique ID defining the zone where the points are contained. Same as the one proposed for ISEA grid	N/A	8	8 bytes integer value
#03	Num_Points	Number of points contained within the zone (if not used, refer to whole file)	N/A	4	4 bytes integer value (for ISEA 4-9, maximum of 2.7M pixels)
		Grid Point Data (repeated NUM_POINTS times)			
#04	Grid_Point _ID	Unique identifier for Earth fixed grid point.	N/A	4	4 bytes (for ISEA 4-9, maximum of 2.7M pixels)
#05	Mask	Flag indicating land/sea USGS content, coastline distance, and Ice content.	N/A	1	1 byte

Field #	Tag name	Description	Units	Bytes	Size
#06	Water_Fraction	Percentage of Water content in the DGG cell, expressed in 0,5% units	N/A	1	1 unsigned byte [0 to 200]

The Mask flag is contained in an 8-bit counter, each bit representing a particular condition for that pixel, and they shall be described using the following convention: [MSB:X X X X:X X X X:LSB]

- USGS Sea Flag:
  - [X X X X:X X X 0] means that the pixel **is not** considered Sea in the USGS Land-Sea mask (water fraction below 95%)
  - [X X X X:X X X 1] means that the pixel **is** considered Sea in the USGS Land-Sea mask (water fraction above 95%)
- USGS Land Flag:
  - [X X X X:X X 0 X] means that the pixel **is not** considered Land in the USGS Land-Sea mask (water fraction above 10%)
  - [X X X X:X X 1 X] means that the pixel **is** considered Land in the USGS Land-Sea mask (water fraction below 10%)
- USGS Mixed Flag:
  - [X X X X:X 0 X X] means that the pixel **is not** considered Mixed in the USGS Land-Sea mask (water fraction below 10% **OR** above 95%)
  - [X X X X:X 1 X X] means that the pixel **is** considered Mixed in the USGS Land-Sea mask (water fraction above 10% **AND** below 95%)
- 200km Coastal flag:
  - [X X X X:0 X X X] means that the pixel has a distance from the coast of **more** than 200 Km (using the MERIS uncertainty map with its coasts extended to 200km)
  - [X X X X:1 X X X] means that the pixel has a distance from the coast of **less** than 200 Km (using the MERIS uncertainty map with its coasts extended to 200km)
- 100km Coastal flag:
  - [X X X 0:X X X X] means that the pixel has a distance from the coast of **more** than 100 Km (using the MERIS uncertainty map with its coasts extended to 100km) e.g. black and grey areas in figure 4
  - [X X X 1:X X X X] means that the pixel has a distance from the coast of **less** than 100 Km (using the MERIS uncertainty map with its coasts extended to 100km) e.g. white area in figure 4
- 40km Coastal flag:
  - [X X 0 X:X X X X] means that the pixel has a distance from the coast of **more** than 40 Km (using the MERIS uncertainty map with its coasts extended to 40km)

- [X X 1 X:X X X X] means that the pixel has a distance from the coast of **less** than 40 Km (using the MERIS uncertainty map with its coasts extended to 40km)

❑ Min Sea-Ice flag:

- [X 0 X X:X X X X] means that the pixel **is not** contained within the Minimum Sea-Ice zone defined for Cryosat
- [X 1 X X:X X X X] means that the pixel **is** contained within the Minimum Sea-Ice zone defined for Cryosat

❑ Max Sea-Ice flag:

- [0 X X X:X X X X] means that the pixel **is not** contained within the Maximum Sea-Ice zone defined for Cryosat
- [1 X X X:X X X X] means that the pixel **is** contained within the Maximum Sea-Ice zone defined for Cryosat

4.16. L1C Pixel Mask

This ADF shall be used for configuring the L1 Processor about the DGG pixels that will be computed for Land or Sea products

As an initial baseline, DGG pixels whose USGS water fraction is lower than 95% are to be processed as Land Pixels during L1 processing, and DGG pixels whose USGS water fraction is higher than 10% are to be processed as Sea Pixels.

4.16.1. Main Product Header

See 4.1.1.

4.16.2. Specific Product Header

See 4.1.2

4.16.3. Data set

The data set shall assign to each pixel in the DGG grid a flag marking it as "to be processed as land" and/or "to be processed as sea". Both values are cumulative, meaning that the pixel will be processed for land and sea. The only categories that will be available now will be land or sea.

This file contains a unique data set with the pixel information. In the same approach as in the DGG, the data set shall be formed by 10 Data Set Records.

Table 26: L1C Pixel Mask Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
		Definition			
#01	L1C_Pixel_Mask	Name describing the Data Set. XML structure containing the variables	Tag		

Field #	Tag name	Description	Units	Bytes	Size
		described below			
Sub-division in Zones					
#02	Zone_ID	Unique ID defining the zone where the points are contained. Same as the one proposed for ISEA grid	N/A	8	8 bytes integer value
#03	Num_Points	Number of points contained within the zone (if not used, refer to whole file)	N/A	4	4 bytes integer value (for ISEA 4-9, maximum of 2.7M pixels)
Grid Point Data (repeated NUM_POINTS times)					
#04	Grid_Point _ID	Unique identifier for Earth fixed grid point.	N/A	4	4 bytes (for ISEA 4-9, maximum of 2.7M pixels)
#05	Mask	Flag indicating whether pixel is to be processed as land and/or sea.	N/A	1	1 byte

The Mask flag is contained in an 8-bit counter, each bit representing a particular condition for that pixel, and they shall be described using the following convention: [MSB:X X X X:X X X X:LSB]

- L1c Land Flag:
  - [X X X X:X X X 0] means that the pixel **shall not** be processed in the L1c Land products
  - [X X X X:X X X 1] means that the pixel **shall** be processed in the L1c Land products
- L1c Sea flag:
  - [X X X X:X X 0 X] means that the pixel **shall not** be processed in the L1c Sea products
  - [X X X X:X X 1 X] means that the pixel **shall** be processed in the L1c Sea products

4.17. L-Band Galaxy Map

For correcting the **Sky** contribution to the reconstruction process, the emission line of the neutral interstellar hydrogen at 1420 MHz should be computed as auxiliary data, as it can reach values over 50

K. The effects can be predicted with a considerable accuracy by calculating the noise temperature arriving to each radiometer's diagram pixel using available maps of the galactic emission at 1420 MHz.

This map shall be also used for calibration of the NIR receivers when the instrument gathers data while pointing at a known deep space position, comparing the measured temperature to the expected one knowing the map and the NIR characterisation. This ADF may be also used for validation of the antenna pattern tables.

The current 1420 MHz map in use in SEPS was produced from observations of the 25-m Stockert telescope of the Bonn University (Germany) for the northern sky and the 30-m observatory at Villa Elisa (Argentina) for the southern sky. This map contains only information surveyed above 16º south equatorial latitude. The latitudes below have been interpolated from a different map measured at 408 MHz with the single-dish telescopes at Jodrell Bank (England), Effelsberg (Germany) and Parkes (Australia) and by multiplying the values by an appropriate conversion factor due to the frequency difference. The angular resolution of this map is 0.25º x 0.25º. The Epoch is B1950.

The map to be used on the L1PP shall be a full sky map at 1420 MHz, which has been already released (Reich, Testori & Reich).

4.17.1. Main Product Header

See 4.1.1.

4.17.2. Specific Product Header

See 4.1.2

4.17.3. Data set

This data set contains the Brightness Temperature values for the Galaxy for the validity period defined in the SPH. Its contents shall be in binary format, and will consist on discrete measurements of Sky brightness temperature in a Right Ascension and Declination grid. This is a rectangular grid spaced 0.25º in each direction.

The Measurement data set shall be formed by several Data Set Records, each one of them representing a matrix of values in the Galaxy map grid. Each row in the matrix will correspond to a fixed Declination (starting at +90º for the first row and ending at –90º for the last row). In turn, every row will be formed by 1441 individual elements, each of them corresponding to one Right Ascension coordinate, starting at 360º and ending at 0º.

Table 27: Galaxy Map Data Set (including all DSR)

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	Galaxy_Map	Name describing the Data Set. Binary structure containing the variables described below	Tag		
Science Data					

Field #	Tag name	Description	Units	Bytes	Size
#02	I	Total Intensity (first Stokes parameter), contained in a 721x1441 real valued matrix.	K	4	721x1441x4 bytes float
#03	Q	Phase difference (second Stokes parameter), contained in a 721x1441 real valued matrix.	K	4	721x1441x4 bytes float
#04	U	Polarisation semi-major axis (third Stokes parameter), contained in a 721x1441 real valued matrix.	K	4	721x1441x4 bytes float
#05	Error	Total Error in the measurements, contained in a 721x1441 real valued matrix.	K	4	721x1441x4 bytes float
#06	Expected NIR_BT	Average NIR polarisation Brightness Temperature expected from the instrument when it is pointing in the coordinates of each matrix element. Contained in a 721x1441 real valued matrix.	K	4	721x1441x4 bytes float
#07	RMS	Flatness of the Galaxy map, expressed as the RMS at –3dB in all points in the grid. It shall be used as an index of the suitability of the instrument pointing for FTT or G matrix calibration. Contained in a 721x1441 real valued matrix.	K	4	721x1441x4 bytes float

I, Q, U and Error values have been retrieved from the Reich, Testori & Reich Galactic Map. Initially only measurements for I are available, although the other elements may be updated during the mission to reflect polarimetric measurements.

The expected NIR Brightness Temperatures are obtained by convoluting the Galactic Map in the respective polarisations with the averaged NIR antenna radiation pattern. The antenna boresight is pointed in each of the grid coordinates directions, and the result of the integral is assigned to that coordinate. EADS CASA Espacio has computed an initial version of the values as described in [RD.12]

The RMS value is computed in a similar manner to the NIR BT, except that the Galactic Map is convoluted with a –3dB beam. The antenna boresight is pointed in each of the grid coordinates directions, and only the pixels within the 3dB cone around boresight are considered. Pixels are first filtered down to the resolution of the PLM, using an ISEA grid to achieve a constant resolution for the entire sphere. EADS CASA Espacio has also computed an initial version of the values as described in [RD.12]

4.18. Sun, Moon and Earth Auxiliary BT maps

In this chapter three different Auxiliary files are covered. They contain brightness temperature models for the Sun, Moon and Earth, which shall be used in the Foreign Sources correction if they are available at the time of processing.

A typical value for the **Sun**'s brightness temperature (T_{SUN}) at L-Band would be 218,000 K, but this value can vary considerably with the solar cycles, making it very difficult to perform an absolute calibration.

The **Moon**'s solid angle is approximately the same as the Sun, but its brightness temperature is much lower than that of the Sun, estimated in around 250 Kelvin at L-band. The measured visibility samples when pointing to the Moon will produce an increase of the brightness temperature of just 0.01 K.

These Auxiliary Files shall contain models for each source, as well as empirical measurements, if possible. They shall be used to compute contributions to be removed at L1. Applicability shall be nominally during reprocessing, as this auxiliary information shall not be available in real time.

The changes in brightness temperature of the sun can be quite big and can be taken into account either through radio telescope measurements or through analytical estimation. UPC has developed a technique to derive the sun's brightness temperature at a given point in time through the data itself. This approach is the one adopted in SEPS and is explained in its Architectural and Detailed Design Document [RD.01] in pages 162-164 of version 4.1.

The contribution of the Earth must be taken into account whenever the instrument is pointing to the Deep Sky, as the Earth shall be entering the back lobes of the antennas, and may influence the calibration results. The model shall be very simple, considering a constant temperature for land sources and a different one for sea sources. This model is still TBD (Open Point #1)

4.18.1. Main Product Header

See 4.1.1.

4.18.2. Specific Product Header

See 4.1.2

4.18.3. Data set

This data set contains the Brightness Temperature values for Sun and Moon for the validity period defined in the SPH. Its contents shall be in binary format, and will consist on discrete measurements of brightness temperature against time. In the near future these external sources shall be modelled as a set of coefficients, expressing the BT value as a function of time. These models are still TBD (Open Point #1), so the initial definition is done providing discrete measurements.

This data set shall be comprised of a number of Data Set Records, each one of them containing the Brightness Temperature measurement of the source and the time of observation.

Table 28: External SUN BT Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	Measured_Temperatures	Name describing the Data Set Record structure. XML structure containing the variables described below	Tag		
Science Data					
#02	Time	UTC time of Brightness Temperature measurement. Expressed in EE CFI transport time format (Array of 3 integer elements)	N/A	12	3*4 bytes First element is signed integer, remaining two are unsigned
#03	Sun_BT_H	Brightness Temperature of the Sun in H polarisation	K	4 bytes	float
#04	Sun_BT_V	Brightness Temperature of the Sun in V polarisation	K	4 bytes	float
#05	Sun_BT_HV_real	Brightness Temperature of the Sun in HV polarisation (real part)	K	4 bytes	float
#06	Sun_BT_HV_imag	Brightness Temperature of the Sun in HV polarisation (imaginary part)	K	4 bytes	float

Table 29: External Moon BT Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					

Field #	Tag name	Description	Units	Bytes	Size
#01	Measured_Temperatures	Name describing the Data Set Record structure. XML structure containing the variables described below	Tag		
Science Data					
#02	Time	UTC time of Brightness Temperature measurement. Expressed in EE CFI transport time format (Array of 3 integer elements)	N/A	12	3*4 bytes First element is signed integer, remaining two are unsigned
#03	Moon_BT_H	Brightness Temperature of the Moon in H polarisation	K	4 bytes	float
#04	Moon_BT_V	Brightness Temperature of the Moon in V polarisation	K	4 bytes	float
#05	Moon_BT_HV_real	Brightness Temperature of the Moon in HV polarisation (real part)	K	4 bytes	float
#06	Moon_BT_HV_imag	Brightness Temperature of the Moon in HV polarisation (imaginary part)	K	4 bytes	float

4.19. VTEC maps

The VTEC (Vertical Total Electron Content) is the content of electrons in a vertical column of 1 m^2 and is expressed in TEC units (1 TECU = 1e+16 e^-/m^2). The product suggested to be used is the IGS Combined, produced by UPC for the IGS - International GPS Service.

The standard products are available with a delay of 11 days and also a rapid product (less than 24 hours) is currently available since the beginning of 2005.

In Fast Processing mode, it is probable that this Auxiliary file shall not be available in time, so the L1PP shall use a default model (IRI2000) as a fallback option. In any case, if the auxiliary file applicable is available, it shall be used instead of the model.

4.19.1. Main Product Header

See 4.1.1.

4.19.2. Specific Product Header

See 4.1.2

4.19.3. Data set

The rapid files are about 840kb in size and are named igsgDDD0.YYi in the same way as the previous, DDD corresponding to the day of year YY (e.g. ckmg0230.03i corresponding to January 23, 2003). Its format is yet to be assessed, as they are provided in ASCII format, and they should be converted to XML files within the SMOS Ground Segment. The ASCII format is described in [RD.02].

4.20. Geomagnetic model

The Geomagnetic model suggested to be used is the IGRF (International Geomagnetic Reference Field) empirical model. Its current status is the 10^{th} generation IGRF generated in December 2004, spanning to the year 2010.

This file contains the spherical harmonics coefficients used in the field modelling valid from the year 2000. These coefficients have been extracted from the IGRF2005 model, which contains the coefficients from the year 1900. The file shall be in ASCII XML format, and the coefficients are given with a degree of accuracy of 1nT.

4.20.1. Main Product Header

See 4.1.1.

4.20.2. Specific Product Header

See 4.1.2

4.20.3. Data set

This file is formed by a unique data set, comprised in turn by three Data Set Records. Each Data Set Record contains the expansion coefficients up to degree 13 of the field model, being one record for the year 2000, another for the year 2005 and the last one for the Secular Variation used in extrapolation beyond 2005.

4.21. Apodisation function

The auxiliary file defining the apodisation function applied contains the discretisation of the apodisation values over the frequency domain coordinates. In this way any apodisation can be expressed as a function of U and V values.

For the Strip Adaptive apodisation, a second table must be used, as it is not possible to express it as a function of only U and V coordinates. This second table will present the coefficients for two cubic equations, which relate the parameters of the 2D Kaiser apodisation window used in Strip Adaptive (α_1, α_2) with the elliptical footprint semi-axes they produce in the antenna frame (w_1, w_2). This relationship is performed in terms of, as seen in RD.13:

$$\log(\alpha_1 \cdot \alpha_2) = A_1(\log(w_1 \cdot w_2))^3 + B_1(\log(w_1 \cdot w_2))^2 + C_1 \log(w_1 \cdot w_2) + D_1$$

$$\log\left(\frac{\alpha_1}{\alpha_2}\right) = A_2\left(\log\left(\frac{w_1}{w_2}\right)\right)^3 + B_2\left(\log\left(\frac{w_1}{w_2}\right)\right)^2 + C_2 \log\left(\frac{w_1}{w_2}\right) + D_2$$

Eq. 2

4.21.1. Main Product Header

See 4.1.1.

4.21.2. Specific Product Header

See 4.1.2

4.21.3. Data set

This data set contains the apodisation coefficients, per each baseline coordinate. Its contents shall be referred in ASCII XML format.

Table 30: Apodisation Coefficients Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	Apodisation_Coefficients	Name describing the Data Set. XML structure containing the variables described below	Tag		
#02	Expression	ASCII representation of the formula used to compute the apodisation coefficients as a function of u,v values. Shall be useful for simple apodisation windows.	N/A	256	256 chars
List Apodisation Coefficients (count=1396)					
#03	List_of_Apodisation_Coefficient	List containing the Apodisation Coefficient data structures, with "count" field (count=1396)	Tag	4	
#04	Apodisation_Coefficient	Name describing the Data Block element. XML structure containing the variables described below	Tag		
#05	U	U baseline coordinate value. Same values as shown in figure 12 of	N/A	10	10 bytes %+010.5f

Field #	Tag name	Description	Units	Bytes	Size
		[RD.10] for the Brightness Temperature Fourier Components in L1b products.			
#06	V	V baseline coordinate value. Same values as shown in figure 12 of [RD.10] for the Brightness Temperature Fourier Components in L1b products.	N/A	10	10 bytes %+010.5f
#07	W	Apodisation coefficient obtained for the previous baseline coordinates	N/A	10	10 bytes %+010.7f

The next table represents the specific contents for the Strip Adaptive apodisation, which contains the cubic coefficients determining the 2D Kaiser parameters as a function of the ellipse desired in the antenna frame.

Table 31: Apodisation Coefficients Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	Apodisation_Coefficients	Name describing the Data Set. XML structure containing the variables described below	Tag		
#02	Expression1	ASCII representation of the formula used to compute $\log((\alpha_1 * \alpha_2)$ as a function of $\log(w_1 * w_2)$.	N/A	256	256 chars
#03	A1	Coefficient for $\log(w_1 * w_2)^3$	N/A	10	10 bytes %+010.7f
#04	B1	Coefficient for $\log(w_1 * w_2)^2$	N/A	10	10 bytes %+010.7f
#05	C1	Coefficient for $\log(w_1 * w_2)$	N/A	10	10 bytes %+010.7f

Field #	Tag name	Description	Units	Bytes	Size
#06	D1	Constant value	N/A	10	10 bytes %+010.7f
#07	Expression2	ASCII representation of the formula used to compute $\log((\alpha_1/\alpha_2)$ as a function of $\log(w_1/w_2)$.	N/A	256	256 chars
#08	A2	Coefficient for $\log(w_1/w_2)^3$	N/A	10	10 bytes %+010.7f
#09	B2	Coefficient for $\log(w_1/w_2)^2$	N/A	10	10 bytes %+010.7f
#10	C2	Coefficient for $\log(w_1/w_2)$	N/A	10	10 bytes %+010.7f
#11	D2	Constant value	N/A	10	10 bytes %+010.7f

4.22. G Matrix

Initially the G matrix shall be defined as the mathematical operator required to transform the complex calibrated visibilities plus the zero frequency value measured through the NIR elements, into reconstructed Brightness Temperature values.

The complete system can be described by a unique G matrix, which takes as input the data produced in all polarisations (H, V and HV). This unique G matrix includes the effect of cross-polarisation antenna patterns into the reconstruction. This G matrix format is the same for all reconstruction methods; the only difference between reconstruction approaches lies in the external elements used to construct it.

If the level of cross-polarisation contamination can be disregarded, because its effect is negligible, this unique G matrix could be used as three separate and smaller G matrices, one for each polarisation. In any case, the file will remain with the same format, and it will be the contents that are read differently.

The purpose of this matrix (or matrices) is to be used for computation of the J matrix operator, which is described in the next chapter.

The SPH shall contain the references to the data used during the generation of such matrix, i.e. which FWF calibration file for the case of UPC G matrix, or which test scenes for the case of CERFACS Stabilized approach.

This description is provided in the ATBD [RD.10], and it shall be analysed together with the Image reconstruction methods to ensure full coherency between them.

4.22.1. Main Product Header

See 4.1.1.

4.22.2. Specific Product Header

See 4.1.2

For this type of ADF, the SPH shall consist of several Reference data sets. The possible Reference data sets shall be the following, according to table 12 of [RD.08]:

Table 32: G Matrix Reference Data Sets

Data_Set Name	Type	Description
L1A_FWF_CAL_FILENAME	MIR_AFWS1A	L1a Fringe Washing Function estimated coefficients used in the computation of the reconstruction G Matrix
AUX_PLM FILENAME	AUX_PLM___	Auxiliary file with PLM characterisation, defining receiver's physical coordinates
AUX_ANT_PATT_FILENAME## (where ## goes from 01 to 72, defining one Reference Data Set per file)	AUX_PATT##	Auxiliary file with receivers' amplitude and phase pattern characterisation used for generation of the G reconstruction matrix

4.22.3. Data set

As mentioned, the unique G matrix format shall be dependant on the input and output variables. For simplification a common format has been selected and is described in [RD.10], such that it can be incorporated in any image reconstruction approach.

For this type of ADF, the Data Block shall consist of one Measurement data set.

The Measurement data set shall be formed by 15996 Data Set Records, each one of them representing a row of the G matrix. In turn, every Data Set Record will be formed by 65536 individual elements, so in reality for this file there shall be two levels of recursion. This recursion shall be handled by the BinXML library.

Table 33: G Matrix Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	G_Matrix	Name describing the Data Set. Binary structure containing the variables described below	Tag		
Science Data					
#02	G_Coefficient	Individual coefficients for the G Matrix, contained in a 15996x65536 real valued matrix. Precise details on the generation procedure can be found in [RD.10]	N/A	8	15996x65536 x8 bytes

Rows in the G matrix shall be ordered as follows:

- The first 2346*2+3 rows shall correspond to H polarisation calibrated visibilities
- The next 2346*2+3 rows shall correspond to V polarisation calibrated visibilities
- The final 3303*2 rows shall correspond to HV polarisation calibrated visibilities

Going into further detail:

- The first 3 rows shall correspond to the zero baselines as measured from the NIR for H polarisation. Order shall be first NIR_AB, then NIR_BC and last NIR_CA
- The next 2346 rows shall correspond to the real values of the H polarisation calibrated visibilities as received from the L1a products, and ordered in the same approach as shown in figure 11 in chapter 4.3.1.3 of [RD.08]. i.e. first element shall be calibrated visibility of LICEF_AB_03 against LICEF_AB_01_H, next shall be LICEF_AB_03 against LICEF_A_01, etc… until the sixty ninth element LICEF_AB_03 against LICEF_C_21. The next element shall then be LICEF_AB_01_H against LICEF_A_01, and so on until LICEF_AB_01 against LICEF_C_21. The next shall be LICEF_A_01 against LICEF_A_02, etc. until LICEF_A_02 against LICEF_C_21. This ordering shall continue until all LICEF correlations have been inserted, and not including correlations with LICEF_NIR in V polarisation (i.e. correlations with receivers LICEF_AB_01_V, LICEF_BC_01_V and LICEF_CA_01_V)
- The next 2346 rows shall correspond to the imaginary values of the H polarisation calibrated visibilities, following the same order as above.
- The next 3 rows shall correspond to the zero baselines as measured from the NIR for V polarisation. Order shall be first NIR_AB, then NIR_BC and last NIR_CA
- The next 2346 rows shall correspond to the real values of the V polarisation calibrated visibilities as received from the L1a products, and ordered in the same approach as shown in figure 11 of [RD.08]. i.e. first element shall be calibrated visibility of LICEF_AB_03 against LICEF_AB_01_V, next shall be LICEF_AB_03 against LICEF_A_01, etc… until the sixty ninth element LICEF_AB_03 against LICEF_C_21. The next element shall then be LICEF_AB_01_V against LICEF_A_01, and so on

until LICEF_AB_01 against LICEF_C_21. The next shall be LICEF_A_01 against LICEF_A_02, etc. until LICEF_A_02 against LICEF_C_21. This ordering shall continue until all LICEF correlations have been inserted, and not including correlations with LICEF_NIR in H polarisation (i.e. correlations with receivers LICEF_AB_01_H, LICEF_BC_01_H and LICEF_CA_01_H). Please refer to figure 11 of [RD.08] for a visual representation of the order followed.

- ❑ The next 2346 rows shall correspond to the imaginary values of the V polarisation calibrated visibilities, following the same order as above.
- ❑ The next 3303 rows shall correspond to the real values of the HV polarisation calibrated visibilities as received from the L1a products, and ordered in the following approach. Please refer to figures 10 and 11 of [RD.09] (orange cells) for a visual representation of the description:
    - First 528 rows with calibrated visibilities of elements in Arm A in H polarisation against elements in Arm B in V polarisation. I.e. first LICEF_AB_03 against LICEF_BC_03, then LICEF_AB_03 against LICEF_BC_01_V, then LICEF_AB_03 against LICEF_B_01, until the 23rd element LICEF_AB_03 against LICEF_B_21. Next is LICEF_AB_01_H against LICEF_BC_03, then LICEF_AB_01_H against LICEF_B_01, and so on until all elements in arm B are correlated with LICEF_AB_01_H (Please note that this row does not include the correlation against LICEF_BC_01_V). This ordering continues until the last element correlated is LICEF_A_21 against LICEF_B_21.
    - Next 528 rows with calibrated visibilities of elements in arm A in H polarisation against elements in arm C in V polarisation. Same order as above, i.e. first LICEF_AB_03 against LICEF_CA_03, then LICEF_AB_03 against LICEF_CA_01_V, then LICEF_AB_03 against LICEF_C_01, until the 23rd element LICEF_AB_03 against LICEF_C_21. Next is LICEF_AB_01_H against LICEF_CA_03, then LICEF_AB_01_H against LICEF_C_01, and so on until all elements in arm C are correlated with LICEF_AB_01_H (Please note that this row does not include the correlation against LICEF_CA_01_V). This ordering continues until the last element correlated is LICEF_A_21 against LICEF_C_21.
    - Next 528 rows with calibrated visibilities of elements in arm B in H polarisation against elements in arm A in V polarisation. Same order as above, i.e. first LICEF_BC_03 against LICEF_AB_03, then LICEF_BC_03 against LICEF_AB_01_V, then LICEF_BC_03 against LICEF_A_01, until the 23rd element LICEF_BC_03 against LICEF_A_21. Next is LICEF_BC_01_H against LICEF_AB_03, then LICEF_BC_01_H against LICEF_A_01, and so on until all elements in arm A are correlated with LICEF_BC_01_H (Please note that this row does not include the correlation against LICEF_AB_01_V). This ordering continues until the last element correlated is LICEF_B_21 against LICEF_A_21.
    - Next 528 rows with calibrated visibilities of elements in arm B in H polarisation against elements in arm C in V polarisation. Same order as above, i.e. first LICEF_BC_03 against LICEF_CA_03, then LICEF_BC_03 against LICEF_CA_01_V, then LICEF_BC_03 against LICEF_C_01, until the 23rd element LICEF_BC_03 against LICEF_C_21. Next is LICEF_BC_01_H against LICEF_CA_03, then LICEF_BC_01_H against LICEF_C_01, and so on until all elements in arm C are correlated with LICEF_BC_01_H (Please note that this row does not include the correlation against LICEF_CA_01_V). This ordering continues until the last element correlated is LICEF_B_21 against LICEF_C_21.
    - Next 528 rows with calibrated visibilities of elements in arm C in H polarisation against elements in arm A in V polarisation. Same order as above, i.e. first LICEF_CA_03 against

LICEF_AB_03, then LICEF_CA_03 against LICEF_AB_01_V, then LICEF_CA_03 against LICEF_A_01, until the 23rd element LICEF_CA_03 against LICEF_A_21. Next is LICEF_CA_01_H against LICEF_AB_03, then LICEF_CA_01_H against LICEF_A_01, and so on until all elements in arm A are correlated with LICEF_CA_01_H (Please note that this row does not include the correlation against LICEF_AB_01_V). This ordering continues until the last element correlated is LICEF_C_21 against LICEF_A_21.

- Next 528 rows with calibrated visibilities of elements in Arm C in H polarisation against elements in Arm B in V polarisation. Same order as above, i.e. first LICEF_CA_03 against LICEF_BC_03, then LICEF_CA_03 against LICEF_BC_01_V, then LICEF_CA_03 against LICEF_B_01, until the 23rd element LICEF_CA_03 against LICEF_B_21. Next is LICEF_CA_01_H against LICEF_BC_03, then LICEF_CA_01_H against LICEF_B_01, and so on until all elements in arm B are correlated with LICEF_CA_01_H (Please note that this row does not include the correlation against LICEF_BC_01_V). This ordering continues until the last element correlated is LICEF_C_21 against LICEF_B_21.
- Next 23 rows with calibrated visibilities of LICEF_AB_01_H against all other receivers in arm A in V polarisation. I.e. LICEF_AB_01_H against LICEF_AB_03, LICEF_AB_01_H against LICEF_AB_01_V, LICEF_AB_01_H against LICEF_A_01, etc… until LICEF_AB_01_H against LICEF_A_21
- Next 22 rows with calibrated visibilities of all receivers in arm A in H polarisation against LICEF_AB_01_V, excluding LICEF_AB_01_H against LICEF_AB_01_V, whose equation is presented in the point above. I.e. LICEF_AB_03 against LICEF_AB_01_V, LICEF_A_01 against LICEF_AB_01_V, etc… until LICEF_A_21 against LICEF_AB_01_V
- Next 23 rows with calibrated visibilities of LICEF_BC_01_H against all other receivers in arm B in V polarisation. I.e. LICEF_BC_01_H against LICEF_BC_03, LICEF_BC_01_H against LICEF_BC_01_V, LICEF_BC_01_H against LICEF_B_01, etc… until LICEF_BC_01_H against LICEF_B_21
- Next 22 rows with calibrated visibilities of all receivers in arm B in H polarisation against LICEF_BC_01_V, excluding LICEF_BC_01_H against LICEF_BC_01_V, whose equation is presented in the point above. I.e. LICEF_BC_03 against LICEF_BC_01_V, LICEF_B_01 against LICEF_BC_01_V, etc… until LICEF_B_21 against LICEF_BC_01_V
- Next 23 rows with calibrated visibilities of LICEF_CA_01_H against all other receivers in arm C in V polarisation. I.e. LICEF_CA_01_H against LICEF_CA_03, LICEF_CA_01_H against LICEF_CA_01_V, LICEF_CA_01_H against LICEF_C_01, etc… until LICEF_CA_01_H against LICEF_C_21
- Next 22 rows with calibrated visibilities of all receivers in arm C in H polarisation against LICEF_CA_01_V, excluding LICEF_CA_01_H against LICEF_CA_01_V, whose equation is presented in the point above. I.e. LICEF_CA_03 against LICEF_CA_01_V, LICEF_C_01 against LICEF_CA_01_V, etc… until LICEF_C_21 against LICEF_CA_01_V

❑ The following and last 3303 rows shall correspond to the imaginary values of the HV polarisation calibrated visibilities as received from the L1a products, and ordered in the approach that has been just described.

Columns in the G matrix shall be ordered in the following way:

- The first 128x128 columns shall correspond to H polarisation Brightness Temperatures
- The next 128x128 columns shall correspond to V polarisation Brightness Temperatures
- The next 128x128 columns shall correspond to the real components of the HV polarisation Brightness Temperatures
- The final 128x128 columns shall correspond to the imaginary components of the HV polarisation Brightness Temperatures

Going into more detail, each distribution of 128x128 elements shall correspond to the SMOS natural hexagonal grid represented in a rectangular matrix. The centre (0,0) shall be the first element of the distribution. The following figures show the resulting xi-eta distribution of values for a 128x128 Brightness Temperature scene using steering 30º of MIRAS instrument:

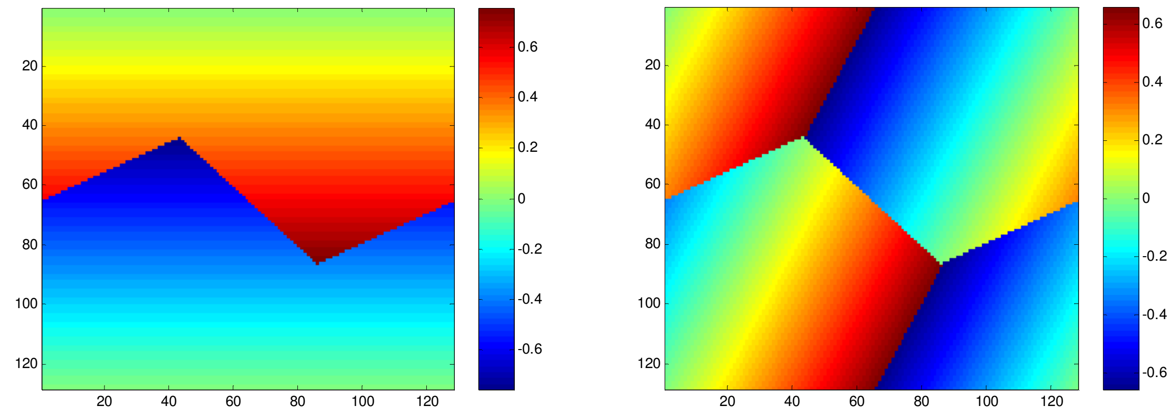

Figure 5: XI (left image) and ETA (right image) coordinates proposed for the G Matrix format

For details on the generation, please refer to chapter 3.2.1 of [RD.10] and chapter 5.3.4 of [RD.11].

The distribution of 128x128 elements shall be arranged in a vector form of 16384 elements, placing elements row after row, as opposed to Matlab that represents them column after column.

4.23. J+ Matrix

This matrix shall represent the mathematical reduction of the previous G matrix in order to obtain Brightness Temperatures frequencies. It represents the System Response Function of the instrument transforming Calibrated Visibilities plus the zero frequency value measured through the NIR elements into Brightness Temperature Frequencies. The computation method shall be described in the corresponding ATBD [RD.10] and L1b DPM [RD.11] documents.

This is the matrix that shall be inverted to complete the Image Reconstruction process. Regardless of how the G matrix is built, the size of the Brightness Temperature grid, or what modelling it has used, its reduction into the J matrix shall always have the same format and size.

The data that shall be stored in this ADF shall be the inverted J, which is called J^+.

4.23.1. Main Product Header

See 4.1.1.

4.23.2. Specific Product Header

See 4.1.2

For this type of ADF, the SPH shall contain one Reference data set. The Reference data set shall be the following, according to table 12 of [RD.08]:

Table 34: J^+ Matrix Reference Data Sets

Data_Set Name	Type	Description
AUX_G_MATRIX_FILENAME	AUX_GMAT__	G Matrix filename used in the J Matrix generation

4.23.3. Data set

The J^+ matrix generation is described in [RD.10], starting from the G Matrix, computing J and inverting it.

For this type of ADF, the Data Block shall consist of one Measurement data set.

The Measurement data set shall be formed by 11164 Data Set Records, each one of them representing a row of the J^+ matrix. In turn, every Data Set Record will be formed by 15996 individual elements, so in reality for this file there shall be two levels of recursion. This recursion shall be handled by the BinXML library.

The format of the contents shall be the following.

Table 35: J+ Matrix Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	J_Matrix	Name describing the Data Set. Binary structure containing the variables described below	Tag		
Science Data					
#02	J_Coefficient	Individual coefficients for the J^+ Matrix, contained in a 11164x15996 real valued matrix. Precise details on the generation procedure can be found in [RD.10]	N/A	8	11164x15996 x8 bytes

The number of columns is now dependant on the u,v frequency domain, and is restricted to the number of non-redundant correlations that the instrument shall be measuring. For MIRAS, the number of non-redundant visibilities is 2791, forming a star shape in the u,v plane, and is only dependant on the number of receivers per arm and the Y shape of the instrument.

Thus, the number of columns for this matrix shall be 11164. This number comes from 1395 complex elements plus one real element that is measured for H or V polarisation, plus 2791 complex elements measured for HV polarisation. Again, the total size of the matrix is dependant on the level of coupling between polarisations through the cross-polarisation antenna patterns. If they can be considered negligible, the J matrix can be split into three separate and independent matrices, one for each polarisation.

4.24. RFI Mask

This auxiliary product shall be based on a mask containing TRUE values for those pixels that are expected to be affected by RFI. It is also possible that this file may be generated as a by-product of the L1c SMOS product files, after analysing the RFI flag in those files.

This file shall be used to fill the information referring to the RFI flag in the L1c products..

The mask shall be expressed in the same Earth Fixed grid as the one used for L1c products, identifying the pixels by their unique identifier. All pixels shall be represented within the mask, even those ones not affected by RFI. This file shall be a binary file.

4.24.1. Main Product Header

See 4.1.1.

4.24.2. Specific Product Header

See 4.1.2

4.24.3. Data set

In the same style as the DGG ADF, this file shall consist of a unique Data Set containing 10 Data Set Records, each one containing a list of points within a zone. These zones are used to allow a fast indexing of the data for search algorithms. They come from the natural decomposition of the icosahedron used in the ISEA projection.

The values presented for each pixel shall be its unique identifier in the Earth Fixed Grid auxiliary file and the RFI flag.

Table 36: RFI Mask Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	RFI_Mask	Name describing the Data Set. XML structure containing the variables	Tag		

Field #	Tag name	Description	Units	Bytes	Size
		described below			
Sub-division in Zones					
#02	Zone_ID	Unique ID defining the zone where the points are contained. An initial approach has 10 zones formed by two adjacent triangles of the main ISEA decomposition.	N/A	8	8 bytes integer value
#03	Num_Points	Number of points contained within the zone (if not used, refer to whole file). To avoid variable size records, the number of points in all zones shall be the same, even if it means that some of them will be dummy.	N/A	4	4 bytes integer value (for ISEA 4-9, maximum of 2.7M pixels)
RFI Data (repeated NUM_POINTS times)					
#04	Grid_Point _ID	Unique identifier for Earth fixed grid point.	N/A	4	4 bytes (for ISEA 4-9, maximum of 2.7M pixels)
#05	RFI_Flag	RFI value of grid point over the ellipsoid. 0 for “No RFI”, 1 for “RFI detected”	N/A	1	1 byte char

4.25. Time Correlation

This auxiliary product simply contains the correlations between UTC time, GPS time, TAI and UT1. These correlations are needed for initialisation of the EE libraries that deal with orbit propagation, attitude computation, etc. Nominally this initialisation is done based on the L0 Ancillary data, but this file shall be used as a backup in case the time correlation information is corrupted.

As of v1.3.0 of L1PP, this file is no longer needed, and time correlations are obtained from the Orbit Scenario File.

4.25.1. Main Product Header

See 4.1.1.

4.25.2. Specific Product Header

See 4.1.2

4.25.3. Data set

This file shall contain a unique Data Set with only one Data Set Record. The information in this DSR shall be defined as a list of the four times and their values at a certain point in time. This is the input required for initialisation of the time and propagation functions of the EE CFI. This file contents shall be in ASCII XML format.

Table 37: Time Correlation Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	Time_Correlation	Name describing the Data Set. XML structure containing the variables described below	Tag		
Science Data					
#02	TAI	TAI time	days	8	8 bytes %+012.8f
#03	UTC	UTC time	days	8	8 bytes %+012.8f
#04	UT1	UT1 time	days	8	8 bytes %+012.8f
#05	GPS	GPS time	days	8	8 bytes %+012.8f

4.26. Flat Target Transformation

This auxiliary product simply contains the averaged correlations measured for all polarisations during deep sky observation. These correlations shall be subtracted from any L1a measurement product in order to apply the Flat Target Transformation before Image Reconstruction. This file shall be a binary file.

4.26.1. Main Product Header

See 4.1.1.

4.26.2. Specific Product Header

See 4.1.2

For this type of ADF, the SPH shall contain several Reference data sets. The possible Reference data sets shall be the following, according to table 12 of [RD.08]:

Table 38: FTT Reference Data Sets

Data_Set Name	Type	Description
L1A_HKTM_FILENAME	TLM_MIRA1A	HKTM filename containing the S/C position and attitude for the snapshots in the current product
L1A_FILENAME	MIR_TARD1A, MIR_TARF1A	L1a Calibrated Visibilities filename obtained in External Target Observation
AUX_GALAXY_ FILENAME	AUX_GLXY__	Galaxy Map used for generation of the Ideal Sky visibilities
AUX_G_MATRIX_FILENAME	AUX_GMAT__	G Matrix filename used in the Ideal visibilities generation

4.26.3. Data set

This file shall contain a unique Data Set with several Data Set Records. The information in these DSR shall be defined as the complete set of correlation values averaged in the external target observation interval. This is the input required for FTT transformation.

Table 39: FTT Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Time Data					
#01	Start_Time	UTC Time at which the Sky Observation sequence was started. Expressed in EE CFI transport time format (Array of 3 integer elements)	N/A	12	3*4 bytes First element is signed integer, remaining two are unsigned

Field #	Tag name	Description	Units	Bytes	Size
#02	Stop_Time	UTC Time at which the Sky Observation sequence was finished. Expressed in EE CFI transport time format (Array of 3 integer elements)	N/A	12	3*4 bytes First element is signed integer, remaining two are unsigned
		Auxiliary Data			
#03	Averaged_Receiver_Temp	Averaged physical temperature of receivers during whole period, expressed in Kelvin.	K	4	4 bytes float
#04	Averaged_NIR_Brightness_Temp	Averaged Brightness temperatures measured at each NIR element, expressed in Kelvin. Two values (H and V) per receiver. Averaging is performed only over each NIR element. Vector array of [6] elements ordered like [NIR_AB_H, NIR_AB_V, NIR_BC_H, NIR_BC_V, NIR_CA_H, NIR_CAV]	K	4	6*4 bytes float
#05	Averaged_FTT_Visib_H	Averaged complex calibrated correlations in H polarisation for all baselines (including redundant, but excluding LICEF-NIR correlations in cross-polarisation). Vector array of [2346] elements	N/A	16	69*34*16 bytes
#06	Averaged_FTT_Visib_V	Averaged complex calibrated correlations in V polarisation for all baselines (including redundant, but excluding LICEF-NIR correlations in cross-polarisation). Vector array of [2346] elements	N/A	16	69*34*16 bytes

Field #	Tag name	Description	Units	Bytes	Size
#07	Averaged_FTT_Visib_HV	Averaged complex calibrated correlations in HV polarisation for all baselines (including redundant). Vector array of [3303] elements	N/A	16	3303*16 bytes
#08	Ideal_Sky_NIR_Brightness_Temp	Brightness temperatures measured at each NIR element for an ideal Sky scene, expressed in Kelvin. Two values (H and V) per receiver. Vector array of [6] elements ordered like [NIR_AB_H, NIR_AB_V, NIR_BC_H, NIR_BC_V, NIR_CA_H, NIR_CAV]	K	4	6*4 bytes float
#09	Ideal_Sky_Visib_H	Ideal Instrument visibilities of the Sky in H polarisation for all baselines (including redundant, but excluding LICEF-NIR correlations in cross-polarisation). Vector array of [2346] elements	N/A	16	69*34*16 bytes
#10	Ideal_Sky_Visib_V	Ideal Instrument visibilities of the Sky in V polarisation for all baselines (including redundant, but excluding LICEF-NIR correlations in cross-polarisation). Vector array of [2346] elements	N/A	16	69*34*16 bytes
#11	Ideal_Sky_Visib_HV	Ideal Instrument visibilities of the Sky in HV polarisation for all baselines (including redundant). Vector array of [3303] elements	N/A	16	3303*16 bytes

Field #	Tag name	Description	Units	Bytes	Size
#12	Ideal_Uniform_NIR_Brightness_Temp	Brightness temperatures measured at each NIR element for a uniform 1K scene, expressed in Kelvin. Two values (H and V) per receiver. Vector array of [6] elements ordered like [NIR_AB_H, NIR_AB_V, NIR_BC_H, NIR_BC_V, NIR_CA_H, NIR_CAV]	K	4	6*4 bytes float
#13	Ideal_Uniform_Visib_H	Ideal Instrument visibilities of a uniform 1Kelvin scene in H polarisation for all baselines (including redundant, but excluding LICEF-NIR correlations in cross-polarisation). Vector array of [2346] elements	N/A	16	69*34*16 bytes
#14	Ideal_Uniform_Visib_V	Ideal Instrument visibilities of a uniform 1Kelvin scene in V polarisation for all baselines (including redundant, but excluding LICEF-NIR correlations in cross-polarisation). Vector array of [2346] elements	N/A	16	69*34*16 bytes
#15	Ideal_Uniform_Visib_HV	Ideal Instrument visibilities of a uniform 1Kelvin scene in HV polarisation for all baselines (including redundant). Vector array of [3303] elements	N/A	16	3303*16 bytes

The order of the visibilities vectors presented above shall be the same as the one presented for the rows of the G matrix in section 4.18.3

4.27. Bistatic Scattering Coefficients

In this chapter the Auxiliary file used to correct Sun glint effect is covered. It contains a look-up table for the bistatic scattering coefficients as a function of incoming radiation incidence angle (θ_o theta_o), relative azimuth between incoming radiation and radiometer look direction (ϕ_s phi_s), radiometer incidence angle (θ_s theta_s), and wind speed (W). The LUT is only function of the input parameters as given in the following table:

Input parameter	Range	increment
Sun incidence angle θ_o [deg, 0=nadir]	0°->90°	5°
Relative azimuth angle between sun and MIRAS observation angle ϕ_s [deg]. This is defined as: phi_radiometer - phi_incoming_sunradiation + 180	0°->360°	5°
MIRAS observation incidence angle θ_s [deg, 0=nadir]	0°->90°	5°
Wind speed [m/s]	7	N/A

Wind speed is currently considered as 7m/s and not supposed to change, although the LUT can be expanded to contain different values for different wind speed values.

4.27.1. Main Product Header

See 4.1.1.

4.27.2. Specific Product Header

See 4.1.2

4.27.3. Data set

This data set contains the Bistatic Scattering Coefficients as a function of several angles, wind speed and polarisation.

This data set shall be comprised of a number of Data Set Records, each one of them containing the Bistatic Scattering Coefficients against a fixed polarisation, wind speed and radiometer incidence angle (θ_s theta_s).

Table 40: Bistatic Scattering Coefficients Data Set Record

Field #	Tag name	Description	Units	Bytes	Size
Definition					
#01	Bistatic_Scattering_Coefficients	Name describing the Data Set Record structure. XML structure containing the variables described below	Tag		
Science Data					
#02	Polarisation	Polarisation value of the Bistatic Scattering Coefficients for the MDR: 0=HH, 1=VV, 2=HV, 3=VH	N/A	2	2 bytes short

Field #	Tag name	Description	Units	Bytes	Size
#03	Windspeed	Wind speed value of the Bistatic Scattering Coefficients for the MDR	m/s	2	2 bytes short
#04	MIRAS_Incidence_Angle	Radiometer incidence angle (θ_s theta_s) value of the Bistatic Scattering Coefficients for the MDR	deg	4	4 bytes IEEE float
#05	Scattering_Coefficients	Bistatic Scattering Coefficients array for a fixed set of θ_o and ϕ_s angles. Matrix array of [19][72] values	N/A	8	19x72x8 double

4.28. Open Points

1. The radiative models for the Sun, Moon and Earth have been replaced by discrete measurements against time.

5. ANNEX: PRODUCT SIZING ESTIMATES

5.1. PMS/NIR Characterisation tables

Assuming a total number of 72 PMS systems, each must be characterised by a set of gain and offset values, spanning over a temperature range. This temperature range should oscillate between 0ºC and 50ºC, so using a 1º step in the on-ground characterisation, the size of the Auxiliary product in binary format would be approximated by the following equation:

$$72\times\left[ID(1byte)+temperature(50bytes)+gain(8\times 50bytes)+offset(8\times 50bytes)\right] \quad \textbf{Eq. 3}$$

This would lead to a PMS ADF size of about 60kB. Even if it were set in ASCII format, with each value represented as a %12.8f format, the size would not be bigger than **170kB**.

For the NIR characterisation the situation is exactly the same, except that there need only be three different characterisations, one per NIR.

The size of this ADF should be considered as negligible compared to the rest of files handled.

These files shall be provided once at the beginning of the mission, once all the values have been characterised on-ground. It is not expected that they will suffer many alterations, only nominal degradation of their elements, so a maximum replacement of once a year is to be expected.

5.2. S-parameters

Considering the amount of data that needs to be present for the Hub and each of the arm sections, and expressing the complex values as %12.8f ASCII format, the following equation would be used to compute the size:

$$\begin{bmatrix} S_{ij}^{HUB\_NS}(5\times 5\times 2\times 12bytes)+ \\ 9\times S_{ij}^{ARM\_NS}(4\times 4\times 2\times 12bytes)+ \\ 12\times S_{ij}^{POWER\_DIV}(8\times 8\times 2\times 12bytes)+ \\ 96\times S_{ij}^{CABLES}(2\times 2\times 2\times 12bytes) \end{bmatrix} \quad \textbf{Eq. 4}$$

The computation yields a total of **31kB** for all NDN S-parameters at a single temperature. If they were measured at changing temperatures, that amount would need to be multiplied by the temperature sampling size. NDN S-parameters are characterised for all elements (power dividers, cables, etc) and at several temperature points.

This file shall be provided once at the beginning of the mission, once all the values have been characterised on-ground. It is not expected that it will suffer many alterations, only nominal degradation of their elements, so a maximum replacement of once a year is to be expected.

This S-parameter format is still under review and pending CASA characterisation.

5.3. Receiver Characterisation

There shall be two efficiency measurements per receiver and polarisation. The receivers' pattern absolute phase shall be measured during IVT at ESTEC and assumed invariant to physical temperature. Expressing the complex values as %12.8f ASCII format, the following equation would be used to compute the size:

$$\left[Eff\,(69\times2\times2\times12bytes) + AbsPhase(69x2x12bytes) \right] \qquad \textbf{Eq. 5}$$

The computation yields a total of **4kB** for all efficiency at a single temperature. If they were measured at changing temperatures, that amount would need to be multiplied by the temperature sampling size.

This file shall be provided once at the beginning of the mission, once all the values have been characterised on-ground. It is not expected that it will suffer many alterations, only nominal degradation of their elements, so a maximum replacement of once a year is to be expected.

5.4. Antenna Patterns

With a rough measurement at 181x181 points in the antenna reference frame in the different polarisations and configurations, the equation giving an estimate of the product size would be the following:

$$69\times\begin{bmatrix} FN_X^{COP}(181\times181\times2\times3\times8bytes) + FN_X^{CROSS}(181\times181\times2\times3\times8bytes) + \\ FN_Y^{COP}(181\times181\times2\times3\times8bytes) + FN_Y^{CROSS}(181\times181\times2\times3\times8bytes) \end{bmatrix} \qquad \textbf{Eq. 6}$$

The computation yields a total of **414MB (or 6MB per receiver)**, which could be increased if measurements are performed throughout a temperature range (unlikely for the moment), or in a bigger sampling grid in the antenna frame.

These files shall be provided once at the beginning of the mission, once all the values have been characterised on-ground. They may be validated in-orbit, so some updates are to be expected. The frequency of these updates is still unknown.

5.5. Discrete Global Grid

ISEA 4-9 grid, as created by the existing software developed by Kevin Sahr, creates an ASCII file containing an incremental counter, a unique point identifier, and the longitude and latitude coordinates of the hexagonal cell centre. It has been improved by adding the averaged altitude of each hexagonal cell over the ellipsoid obtained from the ESA DEM GETASSE30.

The size of the final file is close to **42MB**. Once generated it is not expected to change.

No updates are expected during the mission.

5.6. Land-Sea Mask

The size of the USGS 1km land-sea mask, as stated before is close to **663MB**, due to the fact that is an 8-bit raster image of 17347 lines by 40031 columns. This file shall be used to construct another auxiliary file based on the ISEA grid, containing the grid identifiers and the land-sea flag.

Using this new file, the size is reduced to **13 MB**, as the number of elements is greatly reduced

This file is provided once, although it may be possible to provide updates to it to account for the mask evolution.

5.7. G Matrix

The size of the complete G matrix is still dependant on some analysis to be made regarding the level of decoupling between polarisations. This level of decoupling is measured by the amplitude of the cross-polarisation LICEF radiative patterns, which shall be measured by TUD in the near future. The number of elements in one direction is dependant as well on the resolution wanted for mapping the antenna patterns. In the current case a resolution of 128x128 has been taken, although a smaller one of 64x64 could also be taken.

If the amplitude of the cross-polarisation antenna patterns is above 25dB of the co-polar patterns, with most probability they shall not be neglected, resulting in a bigger G matrix. The size of this G matrix, as described before is based on the number of elements, which currently are 15996x65536. This yields a total size for the complete G matrix of **8GB**.

If, on the other hand, the effect of cross-polarisation patterns can be neglected, the G matrix can be divided into three smaller matrices, two of them with 4695x16384 elements, and one with 6618x32768 elements. This yields a total size of **587 MB** for the former matrices, and **1.7GB** for the latter.

5.8. J Matrix

The size of the complete J matrix is also dependant on the same analysis to be made regarding the level of decoupling between polarisations. The number of elements this time is not dependant on the resolution of the antenna patterns.

If the amplitude of the cross-polarisation antenna patterns is above 25dB of the co-polar patterns, the size of this J matrix, as described before is based on the number of elements, which currently are 15996x11164. This yields a total size for the complete J matrix of **1.4GB**.

If, on the other hand, the effect of cross-polarisation patterns can be neglected, the J matrix can be divided into three smaller matrices, two of them with 4695x2791 elements, and one with 6618x5582 elements. This yields a total size of **100 MB** for the former matrices, and **282 MB** for the latter.

5.9. L-band Galaxy Map

This Galaxy Map has been procured by ESA, based on the Reich&Reich map. It size is 25MB.