DESIS

Data Product Specifications

Doc. ID	DESIS-DLR-ICD-002
Issue	1.3
Date	2015-07-20
Class	Unclassified – Project Internal

DLR

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CHANGE RECORD

Issue	Date	Chapter	Change
1.0	20.07.2015	all	Initial Version
1.1	29.08.2015	Section 6, Section 2.1	On reply to RID-53. Added applicable documents.
1.1	08.09.2015	Section 4.1.1	Added a sentence about not using compression in L1A product components given that DIMS uses its own hardware-based compression. Answer to CDR RID-127
1.1	08.09.2015	Section 4.1.1, section 4.2.1, section 4.3.9, section 4.4.1, section 4.4.2, section 4.4.3, section 4.4.4	Added Log file as part of L1A products stored in DIMS as answer to CDR RID-128.
1.1	08.09.2015	Section 4.1.2, section 4.2.2, section 4.3.3	Removed the Auxiliary data as part of the L1B product delivered to the user. Answer to CDR RID-130.
1.1	08.09.2015	Section 4.1.2, section 4.2.2, section 4.3.3	Changed number of digits for tile number from 2 to 3 to harmonize with sections 4.1.1, 4.1.2, 4.2.1 and 4.2.2. Answer to CDR RID-129.
1.1	08.09.2015	Section 4.3.4	Changed description of the overlapping lines to indicate that it is valid only for L1B products. Answer to CDR RID-132.
1.1	08.09.2015	Section 4.2	Added a paragraph explaining all components in the file name convention used in DESIS. Answer to CDR RID-131.
1.1	08.09.2015	Section 4.3.6	Added quality-1 and quality-2 from L1B quality quicklook file to the L1C quality quicklook. Answer to CDR RID-134.
1.1	09.09.2015	Section 7.1, Section 7.2, Section 8.1, Section 8.2	Added license tags in the metadata cards for L1A, L1B, L1C and L2A products. Examples of xml files are updated. Answer to CDR RID 143
1.1	09.09.2015	Section 7.1, section 7.2	Adding metadata tag <processingNode> for L1A products. Answer to CDR RID 144
1.1	10.09.2015	Section 8.1	Several changes in the metadata. Answer to CDR RID 144
1.1	10.09.2015	Section 8.1, Section 8.2	Grouping of quality metadata. Answer to CDR RID 146
1.1	15.09.2015	Section 4.3.1	Added background value. Answer to RID 104

1.1	21.09.2015	Section 4.1.1	Linearity type specified – response to CDR RID 52
1.1	21.09.2015	Section 5.3.1	Non-linearity correction table changed in response to CDR RID 140
1.1	21.09.2015	Section 5.3.2	Dark current reference table changed in response to CDR RID 101
1.1	22.09.2015	Section 4.4.1, Section 4.4.2, Section 4.4.3	Add table for clarifcation, values copied from L1A Medata- response to CDR RID 138
1.1	23.09.2015	Section 5.3.1	Spectral calibration table was extended by the FWHM in response to RID 108.
1.1	30.01.2015	Section 4.3.3	Changed section name to "Auxiliary data for L1A" in response to RID 132
1.1	01.10.2015	Section 4.1.2, Section 4.2.2	Changed sections to introduce more than one file for the quick-look-quality. Response to RID 133.
1.1	02.10.2015	Section 4.3.6	Quicklook-Quality re-defined in response to RIDs 106, 133, 141.
1.1	02.10.2015	Section 4.2	Added a table to summarize the meaning of the different fields in the product/files naming convention.
1.1	02.10.2015	Section 4.3.6	Change quality layer names from "land" or "water" to "visible land" or "visible water" in response to RID 135.
1.1	08.10.2015	Section 4.3.6	Added 8-bits to all layers of L2A Quality quicklook.
1.1	22.10.2015	Section 4.1.1	Added the overlap lines to the L1A description in section 4.1.1
1.1	22.10.2015	Section 4.1.1	Released version 1.1 of this document including changes after CDR
1.1	18.11.2015	Section 7.1	Specification of metadata cards for DC, CAL, Experimental and Earth data products.
1.1	28.01.2016	Section 4.2., 9.2	Correced missing seconds in naming convention for all examples.
1.1	02.02.2016	Section 4.1.1	Corrected that Auxiliary data exists only for L1A products, that it is generated by L1B processor and user finds the data in L1B, L1C, L2A metadata. L1C and L2A require only the metadata for data processing
1.1	15.03.2016	Section 4.3.2	Corrected section describing the L1A VC file data format to include the change that the VC file shall include also the file headers and session headers that belong to a given L1A data product.
1.1	01.04.2016	Sections 4.1.2, 4.2.2, 4.3.6	GK: Added description for an additional quality layer to ensure compatibility with EnMAP. (L1B)
1.1	04.06.2016	Section 8.1	JA: Change of some of the types of parameters in *.xml metadata

			cards (e.g. string to double)
1.1	08.07.2016	Section 8.1.	JA: range of pixelSize is set from default value 30 m to variable
1.1	25.07.2016	Sections 4.1.2, 4.2.2, 4.3.6	GK: removed changed made at 01.04.2016 following discussion with EC.
1.1	13.10.2016	Section 4.1.1, 4.2.1	Updated DC product definition. Now only 1 DC Image file or VC per product. When 2 DC measurements are taken in the same datatake (e.g. before and after), 2 products will be created with the same datatake number and tile numbers 001 and 002.
1.1	14.10.2016	Section 4.3.1, 4.3.2	Added a note about the endianness of the Spectral Image file and the VC data. Spectral Image is converted to little-endian format by the L1A processor, while VC data are kept as big-endian data.
1.1	14.10.2016	Section 4.3.2	Removed a paragraph that said that no VC data file exists for experimental product. That is not correct. In experimental products L1A processor shall be able to separate the VC data from the image data and create the corresponding product-components of the experimental product.
1.1	30.11.2016	Section 4.3.1	Corrected the description of the format of the L1A Spectral Image file to match that of BIL. Previous description was not for correct.
1.1	16.01.2017	Section 4.2,	Changed definition of Version field in filename to 4 digits ("major.minor" version numbers). Version is the Global Version Number for the processing chain
1.1	16.01.2017	Section 7, 8	Added a new metadata entry "Version" for the global version number of the processin chain. Revision field is kept for the processor version being executed
1.1	16.01.2017	Section 4.3.9, 9.1, 9.2	Changed the name of the metadata entry for the version of the origin/destination from "version" to "revision". Version only applies now to the version of the whole processing chain.
1.1	16.01.2017	Section 4.1, 4.3.3	Changed the extension of the auxiliary L1A data to .tgz and explanation that this .tgz file is obtained by compressing together all auxiliary files
1.1	03.03.2017	Section 8.1	Changed the attitude state vector angle element back to quaternions.
1.1	19.04.2017	Section 5.3.3	Due to the changes in the laboratory calibration procedure for the geometric characterisation additional mounting angles have to be added. These are the nounting angles for the fixed mirror #1 and the POI mirror.
1.1	22.04.2017	Section 7.1	Updates of some Metadata descriptions. No additional ones, No discarded ones -> Intefaces does not change
1.1	32.05.2017	Section 7.1, 8.1	Introduced new metadata. sensorMaxBands, sceneIncidenceAngle. Additionally, sceneAzimuthAngle is part of the L1A metadata. timeGPSFraction has been deleted from L1B metadata and now timeGPS contains also this information as double type with a microsecond resolution.
1.1	02.06.2017	Section 4.3.1	Introduced the duplicated first row for better RS correction

1.1	21.06.2017	Section 4.1.1, 4.1.2, 4.2.1, 4.2.2, 4.3.6	Update of Quality mask of L1A to substitute the dead pixel mask by the detector map. Update of Quality mask of L1B/L1C/L2A to remove the band cross-correlation file and add the defective pixel mask with the new format (e.g. a cube of 235x1024x1024 pixels in L1B).
1.1	22.06.2017	Section 7.1, 8.1	Adding / Changing some metadata in the L1A product Adding: pixelSizeAlong and pixelSizeAcross Changing some value ranges e.g. pointingMirrorAngle for DC/CAL products and changing some description
1.1	03.07.2017	Section 4.3.6	Removed "thin/medium" haze layers. Only one haze type (over land and water) is available for the L2A processor.
1.1	14.07.2017	Section 5	Update of metadata description and addition of metadata
1.1	24.07.2017	Section 4.3.4	Added a description of the main L2A product
1.1	25.07.2017	4.3.6	Removed the QL_QUALITY-2 for S-130 Changed responsibility for S-130
1.1	12.09.2017	8.1	Added test parameter as child of processing element. Now qualitySZA is marked as only part of L2A product.
1.1	09.10.2017	4.3.9	Updated information about log file to indicate that the level of messages for stdout and stderr is specified in the job order.
1.1	30.01.2018	7, 8	Changed metadata for the screening results (discussed proposal was confirmed on 2018-01-26) and updated examples
1.1	31.01.2018	5.4.1, 5.4.2	New chapters for the description of CTB/REF metadata and an XML example have been added according to [TBD14] (after completion, TBD14 was deleted). Note, that new element tags have been included: sensorTotalBands, startSensorBand, endSensorBand, and refTemperature
1.1	07.02.2018	2.1	Reference added
1.1	04.05.2018	7.1, 5.4.1, 5.4.2	Updated the tables and examples with new or renamed metadata cards (startSensorBand=>firstLine, endSensorBand=>lastLine)
1.1	04.05.2018	10	Added [TBE14] for linearity calibration
1.1	04.05.2018	5.1, 5.2	Updated description of calibration and reference table products.
1.1	07.05.2018	5, 5.x	Chapter 5 has been completely revised (except subsection 5.3.3).
1.1	08.05.2018	5.3.2	New structures of the reference tables have been implemented
1.1	14.06.2018		Adding note that definition of binning and shutter mode codes are different in this product specification and the values given in the raw data format
1.1	30.07.2018	4.3.3	Adding description of the product auxiliary file (a copy from 853IDD000X Inreface document)
1.1	06.09.2018	all	Number of digits corrected: data take number = 10, image ID = 13
1.1.	07.09.2018	all	Page numbers corrected, most comments deleted.
1.1	4.10.2018	7.x	Introducing fail save mode
1.1	13.11.2018	5.2.1	Changing meaning of calibration table configuration

1.1	19.11.2018	4.3.6	Change on the quality quicklook bit meaning
1.1	19.11.2018	5.1	Change on the dead pixel mask calibration and reference table bit meaning. Reference table's datatype changed to uint16
1.1	10.12.2018		Changing "visisble" to "clear" in the wording of the mask
1.2	20.11.2019	4.3.8, 4.1.2	Description of ENVI header file component
1.3	12.01.2023	7.1 / 8.1 / 8.3.4	Definition of sceneAzimuthAngle changed for L1C and L2A products

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1. Introduction

1.1 Purpose

This document defines the data files, data formats and data specifications of all DESIS data products used by the different subsystems of the DESIS GS. The purpose of the document is to specify in detail the information about all data exchanged and to serve as reference for the configuration of the subsystems that will process the DESIS data and will deliver them to the user community. The first issue of this document is released in Phase C to be reviewed during the GS CDR. The document in hands is a tailored version of the corresponding document of the DLR-GS to be used at Teledyne Brown Engineering.

1.2 Scope

This document covers in detail the content, format and naming of the DESIS data products which are stored on DIMS (L1A, L1A-DC, L1A-CAL, S1A) as well as the calibration products obtained using the calibration data (calibration tables). This document contains 10 sections:

- Chapters 1-3. These are the usual ECSS prompted introductory chapters.
- Chapter 4: DESIS Data Products. This chapter covers in the contents, data formats and naming conventions used for all DESIS data products in the GS.
- Chapter 5: Internal Calibration and Reference Tables. This chapter covers the contents, data formats and naming conventions used for the internal DESIS calibration and reference products.
- Chapter 6: Reference Information for L1A/L1B Auxiliary Data. Thi chapter covers the details on content and data format for the auxiliary data accompanying the DESIS L0 data and received from systems outside the DESIS instrument.
- Chapter 7: Reference Information for L1A Metadata. This Chapter details all metadata cards 14nnecessary14 the L1A, L1A-DC, L1A-CAL and S1A data products which are stored in DIMS.
- Chapter 8: Reference Information for L1B, L1C, L2A Metadata. This Chapter details all metadata cards 14nnecessary14 the L1B, L1C and L2A data products which are delivered to the user.
- Chapter 9: Reference information for L1A, L1B, L1C, L2A Product History. This Chapter details all metadata cards 14nnecessary14 all DESIS data products (L1A, L1B, L1C, L2A).
- Chapter 10: Open Issues. Contains the list of issues still open or to be defined at the time of writing this document.

2. References

2.1 Applicable Documents

The following documents contain provisions which, through reference in the document on hand, become applicable to the extent specified herein.

Applicability ID and Document Title	Document ID	Issue or Date
[AD01] Interface Control Document	PAV-DLR-TN-001	1.0
[AD02] Ground Segment Overview	PAV-DLR-DD-001	1.1
[AD03] File Format Interface Control Document	MUS-DLR-IC-001	1.7
[AD04] Glossary and Abbreviations	PAV-DLR-TN-005	1.1
[AD05] ATBD L1A, L1B, L1C, L2A Processors	PAV-DLR-TN-004	1.2
[AD06] Time Synchronisation Concept	MUS-DLR-TN-009	1.2
[AD07] Rolling Shutter Mode Operational Concept	MUS-DLR-TN-011	
[AD08] ATBD Vicarious Validation	PAV-DLR-TN-002	1.0
[AD09] Binning and Detector Spectral Channel Mask Operational Concept.doc	MUS-DLR-TN-010	
[AD10] DESIS Telecommand Telemetry and Image File Header Interface Control Document	MUS-DLR-IC-002	1.4
[AD11] Multiple User System for Earth Sensing (MuSES) Ground Segment (GS) to DLR Earth Sensing Imaging Spectrometer – 30 Meter Ground Segment (DESIS-PAV) Interface Definition Document (IDD)	853IDD000X	Revision 10-02
[AD12] DESIS Operation Mode Requirement Specification	MUS-DLR-RS-014	1.1

Table 2-1 Applicable Documents

2.2 Reference Documents

Standards listed below have been used (in the sense of tailoring) to prepare the document on hand. Documents which are recognized best practices are listed for the purpose of information.

Reference ID and Document Title	Document ID	Issue or Date
[RD01] Generic IPF Interface Specification	MMFI-GSEG-EOPG-TN-07-0003	issue 1 revision 8 – 03/08/2009

Table 2-2 Reference Documents

3. Terms and Abbreviations

Terms, definitions, and abbreviations are collected in [AD04].

4. DESIS Data Products

This section introduces the data products generated by the DESIS-PAV GS. Two types of data products can be distinguished:

- Internal products are intermediate DESIS data products generated, stored and managed by the processors part of the GS. They are not available for DESIS data users. The different product types after the L1A processor are internal products.
- User products are DESIS data products that can be delivered to the user (on user request). These products are the L1B processed data, the L1C processed data and the L2A processed data as described in [AD02].

The following subsections describe the different aspects of the DESIS data products. Section 4.1 introduces the DESIS product files and their components. Section 4.2 describes the filename convention and directory structure of the DESIS product files. Finally, section 4.3 describes the data format of each product type component.

4.1 Data product files

We distinguish two type of data products. The internal L1A products stored in DIMS and not distributed to DESIS users and the user L1B/L1C/L2A products generated and delivered to DESIS users according to their request.

4.1.1 DESIS internal L1A product files

Depending on the type of raw input data, four types of L1A products can be created by the L1A processor:

- L1A Earth Product: contains data from an Earth image scene aftertiling. A DESIS Earth datatake is made of lines of 1024 pixels in width (approximately 30 km on ground) times 1024×N lines in height [AD03]. By tiling, the Earth datatake is divided into N scenes of 1024×1024 pixels (approximately 30 km × 30 km on ground) including 16 additional lines which are added at the beginning (8 lines) and at the end (8 lines) of each tile. These additional lines are taken from the previous/next tile (or filled with the background value when no previous/next tile exists) to guarantee a good overlap between tiles of the same datatake. A tile is the minimum amount of DESIS data that can be processed and delivered to the user.
- L1A Calibration Product: contains the different types of calibration measurements (radiometric calibration, spectral calibration/characterization, radiometric linearity investigation) performed with the on-board calibration facilities of the DESIS instrument (radiometric calibration, spectral calibration/characterization, radiometric linearity investigation, etc.).
- L1A DC Product: contains the dark current values of pixels in the DESIS instrument before and/or after each datatake (Earth or Calibration).
- Experimental L1A Product: contains datataken in experimental configuration modes (e.g fixed line mode). These data are of special nature and their analysis requires expert knowledge. L1B, L1C or L2A processors can’t work with this type of data.

All L1A products do not use compression for any of their components. Compression in order to reduce the data volume is 17nnecessary since DIMS uses its own hardware-based compression. Each type of internal L1A data product is described below.

L1A Earth Product:

The L1A Earth Product consists of the components shown in Figure 4-1. One L1A Earth product is generated from each of the tiles of an Earth datatake and it is stored on DIMS.

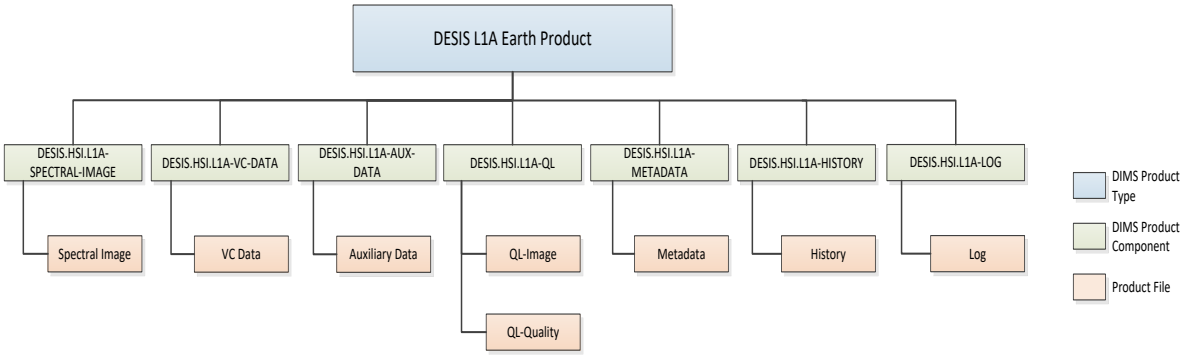

Figure 4-1 Earth L1A Earth Product components

The list of files associated to each product component is listed in Table 4-1.

Name	Description	File Name	File Format	File Size
DESIS.HSI.L1A-SPECTRAL-IMAGE	1 Tile Earth image measurement (30 km × 30 km)	DESIS-HIS-L1A-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-SPECTRAL_IMAGE.bil	Binary (BIL)	500 Mbytes
DESIS.HSI.L1A-AUX-DATA	Auxiliary data	DESIS-HIS-L1A-DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-AUX_DATA.tgz	Binary	< 1 Mbyte
DESIS.HSI.L1A-VC-DATA	Virtual channel data	DESIS-HIS-L1A-DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-VC_DATA.bin	Binary	2 Mbyte
DESIS.HSI.L1A-QL	Image Quicklook	DESIS-HIS-L1A-DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-QL_IMAGE.tif	TIF	6 Mbytes
	Data Quality Quicklook	DESIS-HIS-L1A-DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-QL_QUALITY.tif	TIF	235 Kbytes
DESIS.HSI.L1A-METADATA	Metadata provided by processor	DESIS-HIS-L1A-DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-METADATA.xml	XML	< 1 Mbyte
DESIS.HSI.L1A-HISTORY	History file for L1A processor	DESIS-HIS-L1A-DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-HISTORY.xml	XML	<1 Mbyte
DESIS.HSI.L1A-LOG	L1A processing log file	DESIS-HIS-L1A-DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-LOG.txt	Ascii	<1 Mbyte

Table 4-1 List of L1A Earth Product files

L1A Calibration Product:

The L1A Calibration Product is generated from each of the calibration measurements performed in the DESIS instrument. The L1A Calibration Products are stored in DIMS and they consist of the components shown Figure 4-2. Three different types of L1A Calibration Products are foreseen: RadCal (radiance calibration), SpecCal (spectral calibration) and LinCal (non-linearity). Each calibration type corresponds to a different configuration of the calibration unit and a different number of frames taken for each configuration. The Metadata file of the L1A Calibration Product contains the card ***acquisitionMode*** that identifies the type of calibration employed in each calibration product. The configuration details in each of the different calibration modes (number of frames, number of measurements with different intensities or wavelengths, etc.) are defined in [AD12].

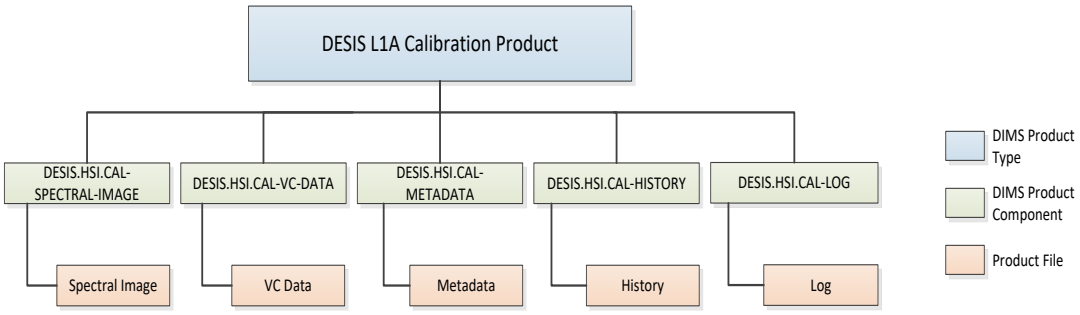

Figure 4-2 L1A Calibration Product components

The list of files associated to each product component of the Calibration product is listed in Table 4-2.

Name	Description	File Name	File Format	File Size
DESIS.HSI.CAL-SPECTRAL-IMAGE	Measurement data from calibration	DESIS-HIS-CAL-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-SPECTRAL_IMAGE.bil	Binary (BIL)	~ 100 Mbyte
DESIS.HSI.CAL-VC-DATA	Virtual channel data for calibration and dark current measurements	DESIS-HIS-CAL-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-VC_DATA.bin	Binary	~ 1 Mbyte
DESIS.HSI.CAL-METADATA	Metadata provided by processor	DESIS-HIS-CAL-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-METADATA.xml	XML	< 1 Mbyte
DESIS.HSI.CAL-HISTORY	History file for L1A processor	DESIS-HIS-CAL-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-HISTORY.xml	XML	<1 Mbyte
DESIS.HSI.CAL-LOG	L1A processing log file	DESIS-HIS-CAL-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-LOG.txt	Ascii	<1 Mbyte

Table 4-2 List of L1A Calibration Product files

L1A DC Product:

A L1A DC Product consists of the components depicted in Figure 4-3. One L1A DC product is generated from each of the DC measurements taken in an Earth or Calibration datatake and it is stored on DIMS. The configuration details for the DC measurements (number of frames before and after) are not defined yet [TBD05].

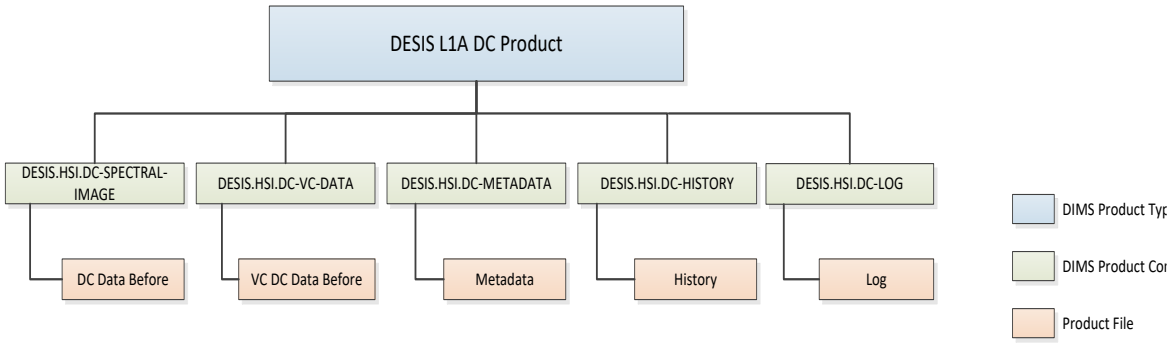

Figure 4-3 L1A Dark Current Product components

The list of files associated to each product component of the DC product is listed in Table 4-3.

Name	Description	File Name	File Format	File Size
DESIS.HSI.DC-SPECTRAL-IMAGE	Dark current measurement data	DESIS-HIS-DC-DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-SPECTRAL_IMAGE.bil	Binary (BIL)	~ 100 Mbyte
DESIS.HSI.DC-VC-DATA	Virtual channel data	DESIS-HIS-DC –DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-VC_DATA.bin	Binary	~ 1Mbyte
DESIS.HSI.DC-METADATA	Metadata provided by pro-cessor	DESIS-HIS-DC –DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-METADATA.xml	XML	< 1 Mbyte
DESIS.HSI.DC-HISTORY	History file for L1A processor	DESIS-HIS-DC –DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-HISTORY.xml	XML	<1 Mbyte
DESIS.HSI.DC-LOG	L1A processing log file	DESIS-HIS-DC –DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-LOG.txt	Ascii	<1 Mbyte

Table 4-3 List of L1A DC Earth Product files

The three digit number after the Datatake number in the file names of the L1A DC products correspond to the different DC measurements found in the original datatake.

L1A Experimental Product:

An experimental L1A product is a L1A Earth product taken in experimental or special observation modes that make not possible to use the standard L1B, L1C, L2A processors on them. These data are processed by L1A processor, stored in DIMS and available for user download but can't be further processed with the standard tools.

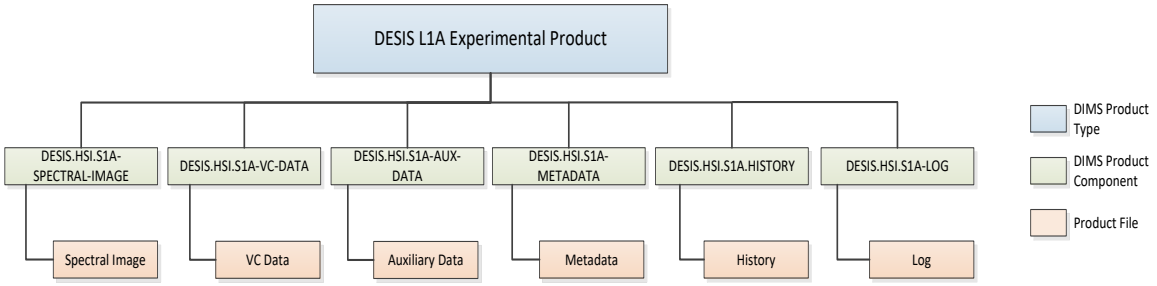

Figure 4-4 Experimental L1A Product components

The list of files associated to each product component in Experimental L1A products is listed in Table 4-1.

Name	Description	File Name	File Format	File Size
DESIS.HSI.S1A-SPECTRAL-IMAGE	Earth image	DESIS-HIS-S1A-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-SPECTRAL_IMAGE.bil	Binary (BIL)	~ 500 Mbyte
DESIS.HSI.S1A-AUX-DATA	Auxiliary data	DESIS-HIS-S1A-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-AUX_DATA.tgz	Binary	< 1 Mbyte
DESIS.HSI.S1A-VC-DATA	Virtual channel data	DESIS-HIS-S1A-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-VC_DATA.bin	Binary	~ 1 Mbyte
DESIS.HSI.S1A-METADATA	Metadata provided by processor	DESIS-HIS-S1A-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-METADATA.xml	XML	< 1 Mbyte
DESIS.HSI.S1A-HISTORY	History file for L1A processor	DESIS-HIS-S1A-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-HISTORY.xml	XML	<1 Mbyte
DESIS.HSI.S1A-LOG	L1A processing log file	DESIS-HIS-S1A-DTnnnnnnnnnn_nnn-<Date>T<Time>-V0100-LOG.txt	Ascii	<1 Mbyte

Table 4-4 List of Experimental L1A Product files

4.1.2 DESIS user L1B/L1C/L2A product files

A user L1B/L1C/L2A data product is a data product processed by the corresponding processor(s) that, under request, is delivered to the user. Any L1B, L1C or L2A Product file consists of the components shown in Figure 4-5. The Product file is generated from the L1A Earth Internal product (case of L1B product) or the previous user product (L1B or L1C) in the DESIS processing chain [AD02]. The requested data product is delivered to the user as a single zip file. The zip file contains the product components in the form of individual files accessible by the user after unzipping the product file. For each tile within an Earth datatake a L1B, L1C or L2A product file is generated at the processing level requested by the user.

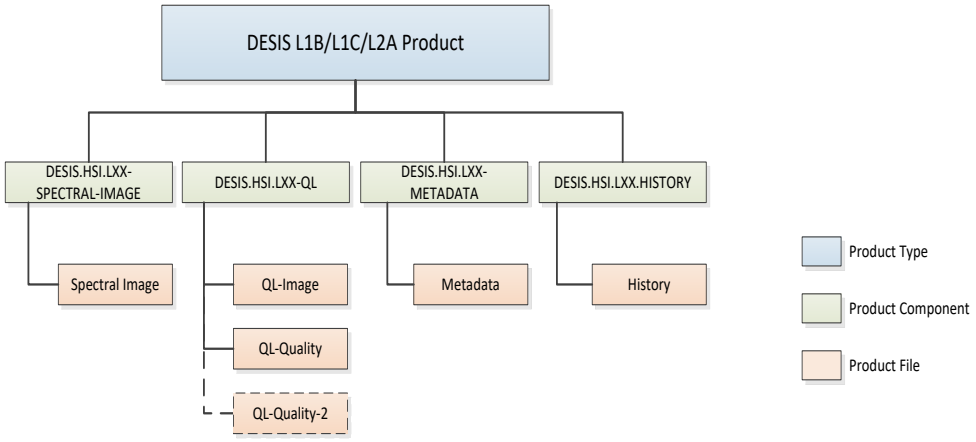

Figure 4-5 L1B, L1C, L2A Product file components. In the figure LXX stands for one of the processing levels L1B, L1C and L2A. The product file shown with a dashed line is only available for L1B data products.

The list of files associated to each product component of the L1B, L1C, and L2A Earth Product is shown in Table 4-5. In addition to the files depicted in Figure 4-5, internal log files are also generated by each processor executed. The log files are not delivered to the user.

Name	Description	File Name	File Format	File Size
DESIS.HSI.LXX-SPECTRAL-IMAGE	Measurement data from Earth datatake	DESIS-HIS-LXX –DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-SPECTRAL_IMAGE.tif	TIF	500 Mbytes
DESIS.HSI.LXX-QL	Image Quicklook	DESIS-HIS-LXX –DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100- QL_IMAGE.tif	TIF	6 Mbytes
	Data Quality Quicklook	DESIS-HIS-LXX –DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100- QL_QUALITY.tif	TIF	Variable (see 4.3.6)
	Data Quality Quicklook-2	DESIS-HIS-LXX –DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100- QL_QUALITY-2.tif	TIF	Variable (see 4.3.6)
DESIS.HSI.LXX-METADATA	Metadata provided by the processors executed	DESIS-HIS-LXX –DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-METADATA.xml	XML	< 1Mbyte
DESIS.HSI.LXX-HDR	Metadata complient to ENVI header	DESIS-HIS-LXX –DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-SPECTRAL_IMAGE.hdr	Ascii	< 1Mbyte
DESIS.HSI.LXX-HISTORY	History file for all processors executed	DESIS-HSI-LXX -DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-HISTORY.xml	XML	<1 MByte
DESIS.HSI.LXX-LOG	Processing log file. Internal, not delivered to the user	DESIS-HSI-LXX -DTnnnnnnnnnn_nnn-<Date> T<Time>-V0100-LOG.txt	Ascii	<1 MByte

Table 4-5 List of files part of an L1B, L1C or L2A Data Product. In the table LXX stands for one of the processing levels L1B, L1C and L2A. The greed shaded row denotes a file delivered only in L2A data products and the red shaded row denotes a file which is not delivered to the user

4.2 Filename and Directory Structure

This section describes the names and directory structure of the files introduced in the previous section. The naming convention for all internal and user files are the following:

DESIS-HSI-<Product_type>-DT<Datatake_ID>_<Tile_ID>-<yyyymmdd>T<hhmmss>-<Version>-<File_identifier>.<Extension>

The meaning of the different items in the file name convention can be found in Table 4-6.

Field	Description
Product_type	One of the possible products stored in DIMS or delivered to the user (L1A, DC, CAL, S1A, L1B, L1C, L2A)
Datatake_ID	Unique number generated by the DESIS instrument when the data are taken (10 digits)
Tile_ID	A 3 digit number (starting at 001) corresponding to the sequential tiles resulting from the tiling process of the L1A processor on the original datatake raw file (Earth datatakes). For calibration and experimental products this number is always 001. For DC products this number indicates the number of the DC measurement in the datatake where the DC measurement was performed (starting at 001).
yyyymmdd	Date when the datatake was started as provided by the DESIS instrument. The format uses 4 digits for the year, 2 digits for the month and 2 digits for the day of the month
hhmmss	Time when the datatake was started according to the timezone used by the DESIS instrument. The format is 2 digits for the hour (24 hours format), 2 digits for the minutes and 2 digits for the seconds
Version	Four digit number specifying the global version of the processing chain used for the generated product (first two digits correspond to the major version number and the last two numbers the minor version number)
File_identifier	Field that identifies the type of file within a given data product. The file identifier can take the values: "SPECTRAL_IMAGE", "VC_DATA", "AUX_DATA", "QL_IMAGE", "QL_QUALITY", "QL_QUALITY-2", "METADATA", "HISTORY" and "LOG"
Extension	File extension associated to each product component file. The allowed values are: "bil", "tgz", "bin", "tif", "xml", “hdr” and "txt"

Table 4-6 Description of the different fields in the name of a data product and associated files

4.2.1 DESIS Internal L1A product filenames

035442L1A processor. All files are stored in DIMS.

L1A Earth Data Product
DESIS-HSI-L1A-DT0010357991_003-20171013T035442-V0100-SPECTRAL_IMAGE.bil
DESIS-HSI-L1A-DT0010357991_003-20171013T035442-V0100-VC_DATA.bin
DESIS-HSI-L1A-DT0010357991_003-20171013T035442-V0100-AUX_DATA.tgz
DESIS-HSI-L1A-DT0010357991_003-20171013T035442-V0100-QL_IMAGE.tif
DESIS-HSI-L1A-DT0010357991_003-20171013T035442-V0100-QL_QUALITY.tif
DESIS-HSI-L1A-DT0010357991_003-20171013T035442-V0100-METADATA.xml
DESIS-HSI-L1A-DT0010357991_003-20171013T035442-V0100-HISTORY.xml
DESIS-HSI-L1A-DT0010357991_003-20171013T035442-V0100-LOG.txt

Table 4-7 Filenames of L1A Earth Product components

Table 4-8 shows the filenames of the L1A Calibration Data product components. All files are stored in DIMS.

L1A Calibration Data Product
DESIS-HSI-CAL-DT0010527398_001-20171223T124100-V0100-SPECTRAL_IMAGE.bil
DESIS-HSI-CAL-DT0010527398_001-20171223T124100-V0100-VC_DATA.bin
DESIS-HSI-CAL-DT0010527398_001-20171223T124100-V0100-METADATA.xml
DESIS-HSI-CAL-DT0010527398_001-20171223T124100-V0100-HISTORY.xml
DESIS-HSI-CAL-DT0010527398_001-20171223T124100-V0100-LOG.txt

Table 4-8 Filenames of L1A Calibration Product components

Table 4-9 shows the filenames of the L1A DC Data product components. All files are stored in DIMS.

L1A DC Product
DESIS-HSI-DC-DT0010410032_001-20171030T225012-V0100-SPECTRAL_IMAGE.bil
DESIS-HSI-DC-DT0010410032_001-20171030T225012-V0100-VC_DATA.bin
DESIS-HSI-DC-DT0010410032_001-20171030T225012-V0100-METADATA.xml
DESIS-HSI-DC-DT0010410032_001-20171030T225012-V0100-HISTORY.xml
DESIS-HSI-DC-DT0010410032_001-20171030T225012-V0100-LOG.txt

Table 4-9 Filenames of L1A DC Product components

Finally, Table 4-10 shows the filenames of the L1A Experimental Data product components. All files are stored in DIMS.

L1A EXPERIMENTAL Product
DESIS-HSI-S1A-DT0010400025_001-20171019T114202-V0100-SPECTRAL_IMAGE.bil
DESIS-HSI-S1A-DT0010400025_001-20171019T114202-V0100-VC_DATA.bin
DESIS-HSI-S1A-DT0010400025_001-20171019T114202-V0100-AUX_DATA.tgz
DESIS-HSI-S1A-DT0010400025_001-20171019T114202-V0100-METADATA.xml
DESIS-HSI-S1A-DT0010400025_001-20171019T114202-V0100-HISTORY.xml
DESIS-HSI-S1A-DT0010400025_001-20171019T114202-V0100-LOG.txt

Table 4-10 Filenames of L1A Experimental Product components

4.2.2 DESIS User L1B, L1C, L2A product directories and filenames

For user products all product files are delivered as a single zip file, for example:

DESIS-HSI-L1B-DT010357991_003-20171013T035442-V0100.zip

After unzipping the file, all products file components are uncompressed under a directory with same name as the original zip file (without the filename extension). The contents of the directory are the file components of the user product listed in Table 4-11. Notice that the LOG file which is generated by the processing chain is not delivered to the user under normal circumstances.

L1B/L1C/L2A User Product	User delivery
DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100	
├DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100-SPECTRAL_IMAGE.tif	Yes
├DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100-SPECTRAL_IMAGE.hdr	Yes
├DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100-QL_IMAGE.tif	Yes
├DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100-QL_QUALITY.tif	Yes
├DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100-QL_QUALITY-2.tif	Yes (only L2A)
├DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100-METADATA.xml	Yes
├DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100-HISTORY.xml	Yes

Table 4-11 Directory name and filenames of L1B/L1C/L2A Earth Product component files (LXX denotes one of these 3 possibilities). The file in the in the green shaded row is delivered only for L2A data products. The LOG file is not delivered to the user

In addition to the files listed in the previous table, the user's product zip file may contain additional files with support information and documentation or a copyright notice.

4.3 Product Description and Formats

This section describes the content and the data format of the files associated to each DESIS data product that were introduced in section 4.1.

4.3.1 Internal L1A Spectral Image

The Product file L1A Spectral Image contains the hyperspectral Earth datatakes from the DESIS instrument, Calibration datatakes and DC datatakes.

The spectral image file contains an image tile where the hyperspectral data are provided in a 3-dimensional data cube. One of the cube dimensions is the spatial direction along the track of the DESIS instrument (Earth datatakes) or along the time sequence (Calibration or DC datatakes). The second dimension corresponds to the direction across the path being followed by the DESIS instrument. Finally, the third dimension is given along the spectral channels. The DESIS data cube is illustrated in Figure 4-7. The data cube can also be seen as a collection of frames taken along time, where a single frame corresponds to a spectral measurement of a single line on Earth on the across track direction (Earth datatake) or a single spectral reading of the DESIS camera during calibration or DC measurements.

Earth datatakes consist of a number of image tiles, each of which is provided as a single DESIS product. Each L1A image tile contains 1024+16 frames within the spectral image file, while the across track (or spatial pixel) direction is fixed to 1024 pixels wide. The extra 16 frames correspond to 8 frames added at the beginning of the file and taken from the end of the previous image tile (if there is a previous tile which is part of the same datatake) and 8 frames added at the end of the file and taken from the beginning of the next image tile (if any). These 8 frames added before and after guarantee a good overlap between tiles of the same datatake. When no previous or next tile exists, the 8 extra frames are filled with background value of 2^16-1 (all bit set to one, unsigned 16 bit value) [AD05]. In case that the RS mode is used, the frame inmediately before the first Earth-image frame of the first tile (only) in a datatake will be filled with a clone of the first Earth-image frame (instead of the background value). This is done to reduce the artifacts on the first RS-corrected Earth-image frame after the RS correction is applied.

The 3-dimensional data structure of each image tile is written to the L1 spectral image file sequentially using a binary file format with pixel data stored as 16 bit unsigned integers in band interleaved by line (BIL) order. The 16 bit unsigned integer values are written in the L1A data products with little-endian format (original big-endian 16 bit values are converted into 16 bit little-endian values by the L1A processor). As an example, for an Earth datatake tile (1040 × 1024 × N spectral channels) the BIL format means that data are written sequentially following the order:

<Frame 0 - Spectral Channel 0 - Spatial Pixel 0> <Frame 0 - Spectral Channel 0 - Spatial Pixel 1> …
…<Frame 0 - Spectral Channel 0 - Spatial Pixel 1023> <Frame 0 - Spectral Channel 1 - Spatial Pixel 0>
<Frame 0 -Spectral Channel 1 - Spatial Pixel 1> …… <Frame 0 - Spectral Channel 234 - Spatial Pixel 1023> <Frame 1 - Spectral Channel 0 - Spatial Pixel 0>< Frame 1 - Spectral Channel 0 - Spatial Pixel 1> …… <Frame 1039 -Spectral Channel 234 - Spatial pixel 1023>

Figure 4-6 Pixel data sequence in an spectral image file for a L1A Earth data product

Spectral bands in DESIS data are numbered from 1 to N in increasing wavelength order. Spatial Pixels (pixels in the across track direction) and Frames (equivalent to moving in the along track direction for Earth datatakes) are numbered from 0 to 1023 (spatial pixels) and N-1 (frames, 1039 for Earth datatake frames).

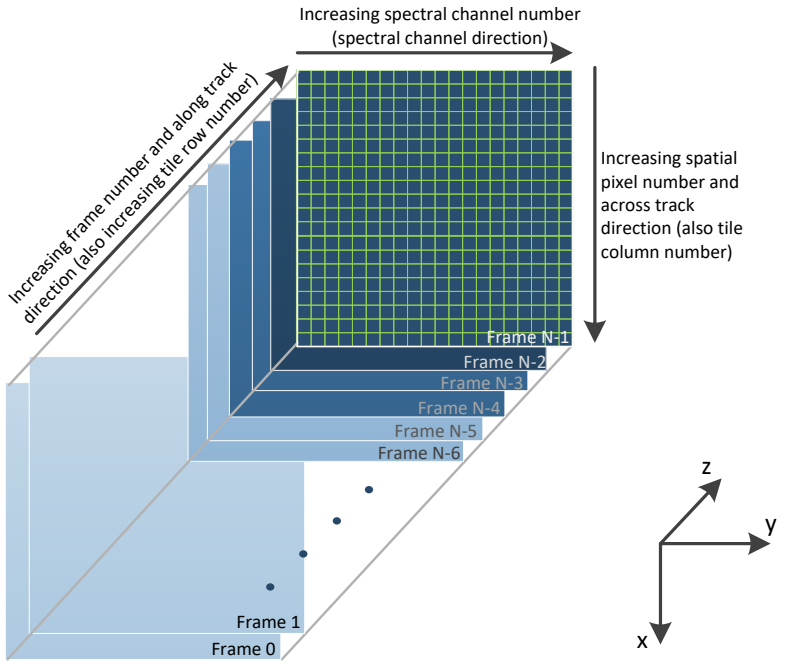

Figure 4-7 Schematic view of the data cube with N frames containing the DESIS hyperspectral data. Spatial pixel number is fixed to 1024 while number of spectral channels and number of frames can vary depending on the type of L1A product and DESIS intrument configuration.

For DC or Calibration files, data are provided with the same structure as Earth datatakes. In this case sequential frames found in the data cube correspond to sequential mesurements along time during the calibration or DC measurement procedures of the DESIS instrument. The number of frames within a calibration or DC L1A product is configurable and can vary. The number of spatial pixels is always 1024.

4.3.2 Internal L1A VC data

VC data contain additional instrument data stored during the image acquisition process. The information is stored in binary format used for the raw data file and it is written to the L1A VC data file following the acquisition sequence of the instrument [AD03].

For each L1A product the VC data file contains the data headers present in the raw data file and the virtual channels data included in each raw data frame used in the current L1A data product. The headers information consists of the File Fixed Header and File Mode Header (defined in [AD03]) as well as all the Session Fixed Headers and Session Mode Headers (defined in [AD03]) that contained frames included in the current L1A data product. Only the DC L1A product contains two sessions, which is 2 x (SessionFixedHeader + SessionModeHeader) with the corresponding VC frames according to low gain and high gain. The number of frames for low gain and high gain measurments must be equal. All other products contain exactly one session information. The headers are simply taken from the original raw file using the same binary format (described in [AD03]) and have a size of 64 Kbytes each. The VC frame data are also taken from the raw file using the same binary format as in the original file and contain additional information from the DESIS instrument. There are 2 VCs per frame (also called frame headers) with a size of 2048 bytes each. The first VC contains information about the ICU and the second VC contains information about the FPA. The VC file part of the L1A data product contains the VC from all frames included in the image tile within a given session. Every L1A VC file shall contain one or more sessions even in the case that the L1A product only contains part of the frames in the original session defined in the raw data file (like in Earth L1A products). In case that more than one session is part of a

L1A product, a new sequence of Session Fixed Header, Session Mode Header and Session frames shall follow until all frames in the L1A product are included following their respective session headers.

In order to correctly read the VC file one has to process the file as a DESIS raw data file that has been stripped of the image information (pixel values). Figure 4-8 shows an example of the data blocks that could be found on a L1A VC file:

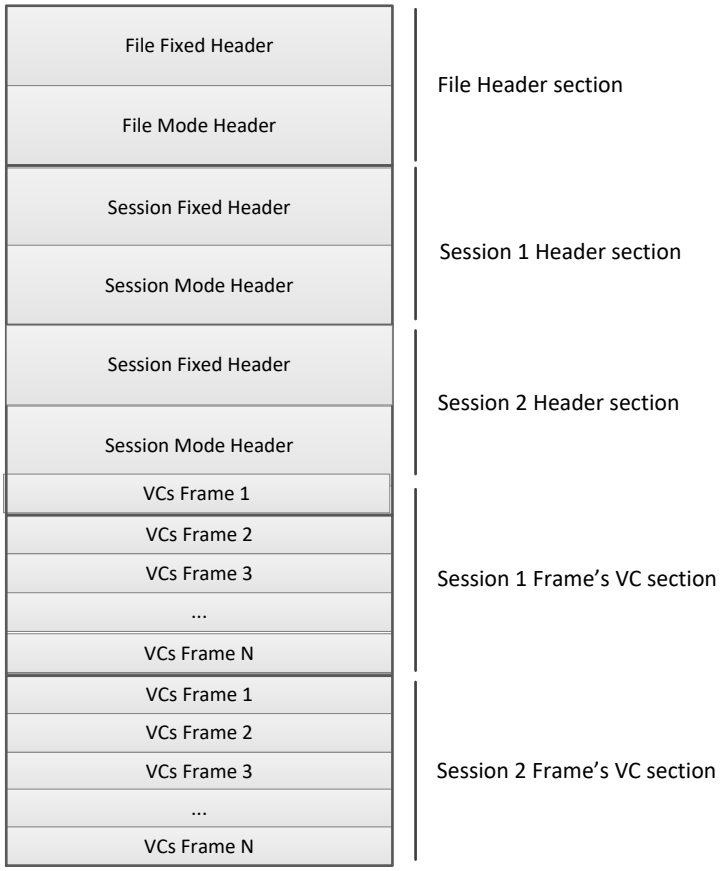

Figure 4-8 Example of the structure of a VC in a DC L1A product. In this case 2 sessions can be found inside the VC file

The number of sessions in a file or frames in a session that are found in the file or session headers written in the VC file, apply to the original raw data file but do not (in general) correspond to the number of sessions/frames in the VC file. The number of sessions and VC frames in a given L1A VC file depends on the type of L1A product as indicated in table Table 4-12:

L1A product Type	Number of sessions	Number of frames per session
Earth	1	1024 (number of rows in scene)
Calibration ([TBD04])	[TBD04]	[TBD04]
Dark Current	1	Number of frames in DC session [TBD05]
Experimental	-	-

Table 4-12 Number of sessions in a L1A VC file for the different types of L1A products

The L1A VC file uses the same binary format as the original raw data file (described in [AD03]). The endianness of the VC data is kept as big-endian, what could make reading of these data more difficult for

the users. For that reason, these data are DESIS instrument internal data only and they are not delivered to users in the delivery products (L1B/L1C/L2A). However, parts of the information contained in the VC data are incorporated into the product metadata accompanying all data products (see section 7 and 8).

4.3.3 Auxiliary L1A data

The auxiliary data file contains information required for DESIS data processing. These data are provided by different instruments/sensors on the MUSES platform or the ISS. Among other important data, the timing, position and altitude information needed for data processing can be found in the Auxiliary data file.

Depending on the number of auxiliary files delivered and their format, the information will be stored into one single file or a single compressed tar file ("tgz" extension) as part of the L1A product. In both cases one single file contains all additional information acompanying every Earth observation datatake or every experimental product.

Contrary to the metadata file that is delivered with all user data products (L1B, L1C, L2A), the auxiliary data file is not delivered as part of the user data products. For that reason, all information relevant for data processing contained in the Auxiliary data file is extracted and included in the metadata file by the L1B processor. L1C, L2A processors require only access to the metadata file to process the data.

The auxiliary data file contains 2 files with the file extension

.pat for the trajectory (see Table 4-13) with the time, position and quaternion and the 32-byte header information

unsigned int hdr_version; //enum ordinal of this header section typedef
unsigned int data_offset; //byte-offset for data elem. from file start
unsigned int data_struct; //enum ordinal of data section typedef
unsigned int platform_id; //enum ordinal of const parameter table
unsigned int num_samples; //number of data samples after header
unsigned int tjuliandate; //Truncated Julian Date (floor-round to 12AM)
double time_length; //length of time in seconds (record duration)

Data Element	Description	Data Type
GPS Time	GPS Second of Day since midnight at header TJD- Note1	Double precision
MGT Time	MGT Time in seconds since MUSES PCU power-up	Double precision
X	X coordinate in Earth Centered, Earth Fixed frame (ECEF) Note 2 in units of meters.	Double precision
Y	Y coordinate in ECEF Note 2 in units of meters.	Double precision
Z	Z coordinate in ECEF Note 2 in units of meters.	Double precision
Q_W	Scalar component of body-to-ground quaternion Note 3, Note 4	Double precision
Q_X	X-axis component of body-to-ground quaternion	Double precision
Q_Y	Y-axis component of body-to-ground quaternion	Double precision
Q_Z	Z-axis component of body-to-ground quaternion	Double precision

Note 1: GPS time is not perturbed by leap seconds. TJD=4244 + GPSAbsoluteSecond/86400. GPSAbsoluteSecond is the total count of seconds since the beginning of GPS time at UTC midnight Jan 6, 1980.
Note 2: Earth Centered, Earth Fixed (ECEF) Coordinate System, also known as the Earth-Centered Rotational (ECR), is defined in Appendix E. Datum is ITRF2008 frame near identical to IGS08 or WGS84.
Note 3: The pointing vector is relative to the center of the inner platform of MUSES. This is referred to as the Plat-

Data Element	Description	Data Type
	form Frame (frame 'P') in the MUSES Software Requirements Document. Thus the location and attitude will include all lever arm and boresight corrections up to the P frame. DLR will need to compute both the lever arms and the boresight angles relative to the center of 'P'.	
Note 4:	A vector oriented relative to the Platform coordinate system axes and pre-multiplied by R(body-to-ground) will yield a vector oriented relative to the ECEF axes.	

Table 4-13 Trajectory File Data elements

and **.sdev** for the accuracy file (see Table 4-14) with accuracy assessments for each smoothed position for subsequent geolocation

Data Element	Description	Data Type
X-position std dev	Estimated X position standard deviation error in meters	double precision print %8.3f
Y-position std dev	Estimated Y position standard deviation error in meters	double precision print %8.3f
Z-position std dev	Estimated Z position standard deviation error in meters	double precision print %8.3f
X-rotation std dev	Estimated angle standard deviation around X-axis error in arc-minutes	double precision print %8.6f
Y-rotation std dev	Estimated angle standard deviation around Y-axis error in arc-minutes	double precision print %8.6f
Z-rotation std dev	Estimated angle standard deviation around Z-axis error in arc-minutes	double precision print %8.6f

Table 4-14 Accuracy file data elements

4.3.4 User Product L1B, L1C, L2A Image

The product Image file is a binary file in tif format. The data from each spectral channel are stored in 16 bit unsigned integer format using one image layer per band. The image size is 1024×1024 pixels for L1B data products. The 16 overlapping image lines (8 before and 8 after the image tile) in L1A products are not included in the L1B image files. After L1C processor the image is generally rotated and the size is different from the original 1024×1024 pixel size. The number of chanels in the image corresponds to the number of bands in the original DESIS data. L2A processor image product has the BOA reflectances with the same size, projection and number of bands as L1C.

4.3.5 Product L1A, L1B, L1C, L2A Quicklook-image

The quicklook image file is a tif file with the same size as the data image and three 8-bit channels. Values from the original image are transformed to 8-bit pixel values and radiometrically adjusted for optimal display. For the quicklook generation the following channels will be used: 500nm (blue), 650 nm (red), and 850nm (infrared).

The quicklook image in L1A and L1B data products is generated by the L1A processor. The quicklook image of L1C and L2A products is generated by the L1C processor or the L2A processor using the georeferenced main image data.

4.3.6 Product L1A, L1B, L1C, L2A Quality-quicklook

Quality layers are generated during each processing task and added to the quality-quicklook file in order to complement the output image with pixel-level quality information of the output product. The Quicklook-quality information is delivered in one or more tif image files with different number of layers. The number of layers, format and description of the content changes for each processing stage.

L1A Earth Data Product:

The L1A quality quicklook component contains one single file ("QL_QUALITY") that provides the Detector Map (DM) of the DESIS sensor. The DM is a bandwise column average of the spectral image values defined in [AD05]. The format of the quality file is tif and includes two 16-bit layers with the same geometry as the DESIS sensor. The size of the quicklook is 1024 × N_{bands} , where N_{bands} is the number of channels after binning in the corresponding datatake. The maximum number of bands is 235 for the no-binning case. An schematic view of the L1A quality quicklook is shown in Figure 4-9.

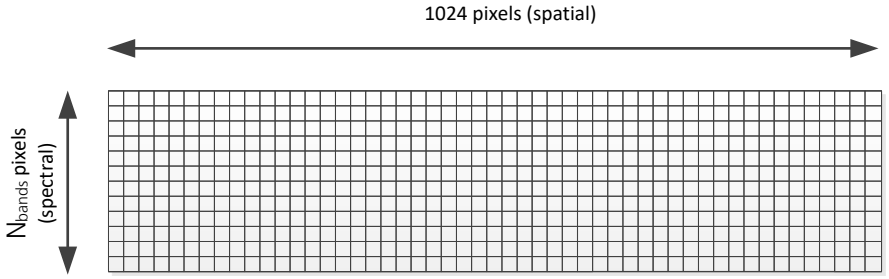

Figure 4-9 Image size of each layer in the quality quicklook in the L1A data product.

The information contained in the layers of the quicklook image is described in Table 4-15.

Layer	Value definition	Remark
Layer-1 (16 bits)	Detector mask uncalibrated. For each pixel with spatial coordinates "i" and "j" in the quicklook layer this value indicates the bandwise column average of the Spectral Image rows before radiometric calibration	16 bit unsigned integer. The values correspond to Digital Numbers
Layer-2 (16 bits)	Detector mask calibrated. For each pixel with spatial coordinates "i" and "j" in the quicklook layer this value indicates the bandwise column average of the Spectral Image rows after radiometric calibration	16 bit unsigned integer. These values are in radiance units

Table 4-15 Quality layers of the L1A quality quicklook file-1 ("QL_QUALITY")

L1B Data Product:

After the execution of the L1B processor, a quality quicklook file is generated, which is an image in tif format that defines the location of the degraded quality pixels.

The quality file ("QL_QUALITY") contains N_{bands} 8 bit layers with a size of 1024×1024 pixels. The value 1024 comes from the number of spatial pixels and the number of lines (frames) included in the image tile. The value N_{bands} corresponds to the number of bands used in the datatake and it is 235 when no binning is used to acquire the data. Each layer of the QL_QUALITY file corresponds to one of the acquisition bands and contains information about the quality of the image pixels in that band encoded as a 8-bit mask. All the pixels flagged with any of the monitored quality indicators, see [AD05], will be set to 1. Moreover, every surrounding pixel affected at some degree by these flagged pixels will also be set to 1. one of these problems is found in a pixel the corresponding bit of the mask will be set to 1. The association from pixel

problems to mask bits is given in Table 4-16. Not used bits will provide the opportunity to implement in the future more complex degraded quality pixel definition policies.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Not Used	Unreliable Calibration	Manufaturing defects	No data	Low Radiance	High Radiance	Suspicious	Dead

Table 4-16 Description of the bits in the bit mask used in quicklook file "QL_QUALITY" of L1B

Table 4-17 shows how to interpret the values contained in the quality file “QL_QUALITY”. More details about the quality estimation of the image pixels and how this quality file is filled can be found in [AD05] and [AD08].

Layer	Value definition	Remark
Layer-1 (8 bits)	Pixel quality mask, the value of a pixel in position "i-j" in layer "1" indicates: − 0 : Pixel in line "i", row "j" in band "1" of the image tile is marked as good − 1 : Pixel in line "i", row "j" in band "1" of the image tile has degraded quality	Only the first bit is used.
…	…	…
Layer-N_{bands} (8 bits)	Pixel quality mask, the value of a pixel in position "i-j" in layer "N_{bands}" indicates: − 0 : Pixel in line "i", row "j" in band "N_{bands}" of the image tile is marked as good − 1 : Pixel in line "i", row "j" in band "N_{bands}" of the image tile has degraded quality	Only the first bit is used.

Table 4-17 Interpretation of the mask values in quality file “QL_QUALITY” of L1B products

More details on the method used to derive the values written in the quality layers of the L1B data products can be found in [AD05] and [AD08].

L1C Data Product:

The quality quicklook of L1C data products consists of one file in tif format. This file, "QL_QUALITY", contains the same information as the "QL_QUALITY" file of L1B product, previously described, but resampled to the new grid resulting from the orthorectification process of the L1C product. The resampling is done using the method described in [AD05]. In this case the mask of a pixel can't be directly interpreted as a pixel affected by the problems reported in the mask, but as a pixel resulting from the interpolation of pixels affected by the problems reported in the mask. The mask is provided as an indication of the pixel reliability.

The interpretation of the values in the masks of QL_QUALITY is shown in Table 4-18.

Layer	Value definition	Remark
Layer-1 (8 bits)	Pixel quality mask, the value of a pixel in position "i-j" in layer "1" indicates: − 0 : L1C resampled pixel in line "i", row "j" in band "1" of the image tile is marked as good − 1 : L1C resampled pixel in line "i", row "j" in band "1" of the image tile is affected by pixels with degraded quality	Only the first bit is used.
…	…	…

Layer	Value definition	Remark
Layer-N_{bands} (8 bits)	Pixel quality mask, the value of a pixel in position "i-j" in layer "N_{bands}" indicates: − 0 : L1C resampled pixel in line "i", row "j" in band "N_{bands}" of the image tile is marked as good − 1 : L1C resampled pixel in line "i", row "j" in band "N_{bands}" of the image tile is affected by pixels with degraded quality	Only the first bit is used.

Table 4-18 Interpretation of the mask values in quality file "QL_QUALITY" of L1C products

L2A Data Product:

L2A data products have two tif files as part of the quality quicklook. The first one is a copy of the "QL-QUALITY-1" file from the L1C product and it is already described in Table 4-18.

The second quality file ("QL_QUALITY-2") contains new mask layers added by the L2A processor. For the first file, the complete list of quality layers contained in the tif file is shown in Table 4-19. Each of the layers of the tif quality quicklook is a 8-bit layer. Details about the meaning of each of this quality layers and the methods used to obtain them can be found in [AD05] and [AD08].

Layer	Value definition	Remark
Layer-1 (8 bits)	Shadow pixel, a 0/1 value for each pixel in the quicklook with spatial "i" and "j" coordinates indicating: − 1: Pixel "i-j" is a Shadow pixel − 0: Pixel "i-j" is a Non shadow pixel	1 bit used (lowest significance bit)
Layer-2 (8 bits)	Clear land pixel, a 0/1 value for each pixel in the quicklook with spatial "i" and "j" coordinates indicating: − 1: Pixel "i-j" is a visible land pixel − 0: Pixel "i-j" is a Non visible land pixel	1 bit used (lowest significance bit)
Layer-3 (8 bits)	Snow pixel, a 0/1 value for each pixel in the quicklook with spatial "i" and "j" coordinates indicating: − 1: Pixel "i-j" is a Snow pixel − 0: Pixel "i-j" is a Non snow pixel	1 bit used (lowest significance bit)
Layer-4 (8 bits)	Haze over land pixel, a 0/1 value for each pixel in the quick-look with spatial "i" and "j" coordinates indicating: − 1: Pixel "i-j" is a Thin haze over land pixel − 0: Pixel "i-j" is a Non thin haze over land pixel	1 bit used (lowest significance bit)
Layer-5 (8 bits)	Haze over water pixel, a 0/1 value for each pixel in the quick-look with spatial "i" and "j" coordinates indicating: − 1: Pixel "i-j" is a Thin haze over water pixel − 0: Pixel "i-j" is a Non thin haze over water pixel	1 bit used (lowest significance bit)
Layer-6 (8 bits)	Cloud over land pixel, a 0/1 value for each pixel in the quick-look with spatial "i" and "j" coordinates indicating: − 1: Pixel "i-j" is a Cloud over land pixel − 0: Pixel "i-j" is a Non clound over land pixel	1 bit used (lowest significance bit)
Layer-7 (8 bits)	Cloud over water pixel, a 0/1 value for each pixel in the quicklook with spatial "i" and "j" coordinates indicating: − 1: Pixel "i-j" is a Cloud over water pix-el − 0: Pixel "i-j" is a Non clound over wa-	1 bit used (lowest significance bit)

Layer	Value definition	Remark
	ter pixel	
Layer-8 (8 bits)	Clear water pixel, a 0/1 value for each pixel in the quicklook with spatial "i" and "j" coordinates indicating: − 1: Pixel "i-j" is a visible water pixel − 0: Pixel "i-j" is a Non visible water pixel	1 bit used (lowest significance bit)
Layer-9 (8 bits)	Aerosol optical thickness value computed during L2A processing	Value is encoded in a 8-bit unsigned integer value (0-255 range)
Layer-1010 (8 bits)	Perceptible water vapour value computed during L2A processing	Value is encoded in a 8-bit unsigned integer value (0-255 range)

Table 4-19 Quality layers of the L2A quality quicklook file-2 ("QL_QUALITY-2")

4.3.7 Product Metadata L1A, L1B, L1C, L2A

The Product Metadata is part of every data product of the L1A, L1B, L1C and L2A processors. It is written using XML format and it contains information on file metadata, job processing and product specific parameters. The structure of the Product Metadata file consists of 5 information blocks:

- File Metadata information, containing general information about the metadata file itself and copyright notice
  Processing parameters (only L1B, L1C, L2A products), containing general information about the processing parameters of the product (e.g. product format, type, resampling, map projection)
- Base parameters, containing basic information about the data (e.g. location, time, processing level)Specific parameters, containing DESIS mission specific parameters
- Product specific parameters (only L1B, L1C, L2A products), containing parameters which are specific of a particular product level

For L1A data products section 7.1 contains the full description of all fields in the Product Metadata file and section 7.2 a sample Product Metadata file. For L1B, L1C and L2A data products 8.1 contains the full description of all fields in the metadata file, section 8.2 contains a sample product metadata file and section 8.3 explains in detail some of these metadata values.

4.3.8 ENVI Product Metadata L1B, L1C, L2A

Each L1B, L1C and L2A product contains an ENVI header file (for processor SW versions starting with V02.07) for the SPECTRAL image. The following additional tags are included in the ENVI header file

- wavelength units
- data ignore value
- wavelength
- fwhm
- data gain values
- data offset values

“file type” and “interleave” are set to the “tiff” format of the spectral image data cube.

4.3.9 Product History L1A, L1B, L1C, L2A

The Product History file is a file acompanying every L1A, L1B, L1C or L2A data product and it contains information about the executed processing steps and the items that were used to produce the data product. The file is written in XML format and contains a nested structure where each data product description contains the description of the data products used for its generation.

Section 9.1 contains the full description of all fields in the Product History file and section 9.2 a sample Product History file.

4.3.10 Internal Product Log L1A, L1B, L1C, L2A

The Product Log file is a file generated during the execution of a processor (L1A, L1B, L1C and L2A) that contains logging information of the tasks performed by the processor that delivered the data product. The file is written in Ascii format following the ESA IPF Standards [RD01]. Processor messages are syslog style ASCII strings of variable length and terminated with NL character.

Each line contained in the Log file is format as follows:

- Date/Time: yyyy-MM-ddThh:mm:ss.nnnnnn
- Node Name: received by gethostname()
- Processor Name: L1A, L1B, L1C, L2A
- Processor Revision: nn.nn
- Process ID (PID): [getpid()]
- Message type: [X] where X is one of the options shown in Table 4-20

[X]	Type of Message	Recommended Channel
[D]	Debug: Software tracing messages	Stdout
[I]	Informational: Information about kind or status of operationis	Stdout
[P]	Progress: Information on progress of operations	Stdout
[W]	Warning: An error occurs and the processor is able to continue	Stdout
[E]	Error: An error occurs and the processor can not continue	Stderr

Table 4-20 Message Types in Log files and the default output channel

- Text: free text info

A colon character is used to separate the message type and text from the other fields in each log file line. Each entry of a log file shall be formatted as in the following example:

```
2015-09-24T04:02:07.458000 thales L1B 01.04 [0000013875]: [I] Processor starting.
Config file is /home/work/Joborder-L1B.xml
```

The Log output is sent to the stdout and stderr as specified on ESA IPF Standards [RD01], but a copy of both streams is sent to the Log file written during the processor execution. Two message threshold levels (one for stdout and one for stderr) defined in the joborder files define the destination of each message type. The recommended destinations are shown in the third column of Table 4-20. The log file is not delivered to the user (L1B, L1C, L2A processors) and its main purpose is to identify problems on the processor execution and help on software debugging.

5. DESIS Internal Calibration and Reference Products

The DESIS GS creates and uses different files for calibration, for quality control and for monitoring of the DESIS instrument and its data. These can be separated into 2 types of internal products:

- ***Calibration table files*** - derived from pre-launch and onboard calibration measurements
- ***Reference table files*** - created for comparison of onboard calibration measurements to references from pre-launch or onboard measurements.

This chapter describes in detail these files and their contents.

5.1 Calibration and Reference Table Products

This section describes the content of the Calibration and Reference table products used in the DESIS GS.

5.1.1 Calibration table products

On-board calibration tables

Each L1A calibration product (see 4.1.1) results from a radiance calibration measurement, a spectral calibration measurement, or a non-linearity calibration measurement [TBD14]. They make use of the internal calibration unit, comprising two sets of monochromatic and white LED's in the corresponding calibration mode. The calibration products are generated with the L1A processor from calibration datatakes and are stored on a database which serves as the basis for the creation of the internal calibration and reference table products.

Following types of on-board calibration tables exist for the processing of DESIS data:

- Spectral calibration table
- Radiometric calibration table
- Dead Pixel Mask calibration table
- Linearity calibration table (if existing)

The calibration table product structure is illustrated in Figure 5-1.

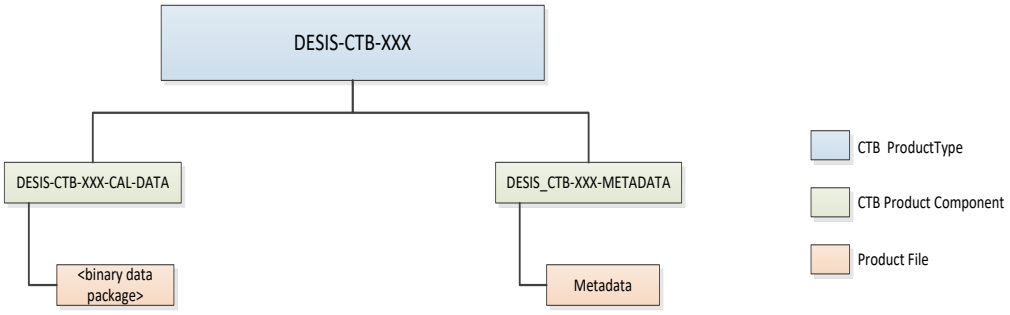

Figure 5-1 Calibration table product

There are two product components for each calibration product type:

- CTB_XXX-CAL-DATA (calibration or correction files for calibration mode XXX)
- CTB_XXX-METADATA (metadata for calibration tables)

Where XXX is one of the on-board calibration modes described in Table 5-1.

Calibration Type	Name
RAD	Radiometric calibration table
SPE	Spectral calibration table
DPM	Dead pixel mask calibration table
LIN	Non-linearity calibration table

Table 5-1 On-board calibration table product types

Geometric calibration table

Similarly to on-board calibration tables, the geometric calibration table is first obtained from laboratory calibration measurements and later updated using the DESIS data. The geometric calibration table product structure is illustrated in Figure 5-2.

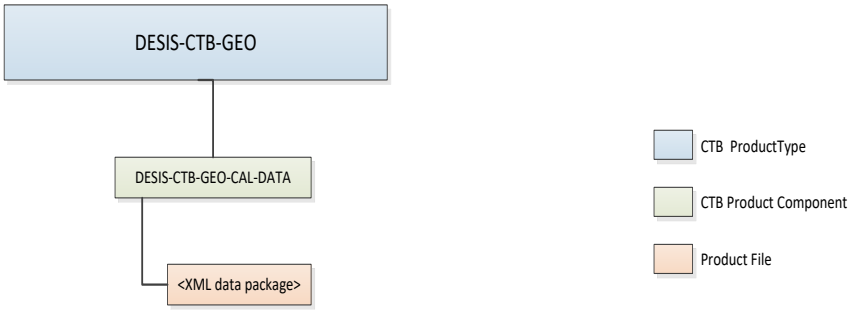

Figure 5-2 Geometric calibration data product

In this case the calibration product consists of one single file. There is no additional metadata file, since the calibration table can be considered as an excerpt of the L1B data product metadata (see 8.1). For the geometric calibration only one type of calibration table exists.

5.1.2 Reference table products

In addition to the calibration table products, there are further table products which are used as references for the offline processing of calibration measurements to derive the calibration tables. They contain the reference values for the comparison of a current calibration measurement to reference values obtained from pre-launch or a valid on-board calibration. The reference values are time averaged over all frames of the corresponding calibration measurement. The standard deviation is also stored for statistical purposes and quality control.

For the processing of DESIS data, following types of reference tables exist:

- Spectral reference table
- Radiometric reference table
- Linearity reference table (if existing)
- Dark current reference table
- Dead pixel mask reference table

The reference table product structure is illustrated in Figure 5-3.

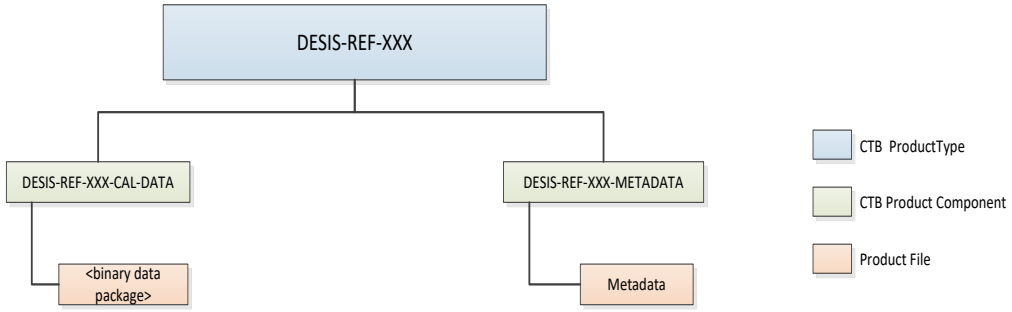

Figure 5-3 Reference table product

There are two product components for each reference product type:

- REF-XXX-CAL-DATA (reference file for calibration mode XXX)
- REF-XXX-METADATA (metadata for reference tables)

Where XXX is one of the on-board reference tables described in Table 5-2.

Calibration Type	Name
RAD	Radiometric reference table
SPE	Spectral reference table
LIN	Linearity reference table
DAR	Dark current reference table
DPM	Dead pixel mask reference table

Table 5-2 On Board reference table product types

5.2 Calibration and Reference Products Filenames

5.2.1 Calibration products filenames

Table 5-3 describes the product type, naming, format and size of the calibration tables. The size depends on the binning mode and is calculated here for data without binning, i.e. binning mode “1”. The size of the CAL-DATA files is approximately inversely proportional to the binning factor (= binning mode).

Product Type/Component	File Name	Description	Size (MiB)	For-mat
DESIS.HSI.CTB-RAD-CAL-DATA	DESIS-CTB_RAD-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-TABLE.bin	DESIS radiometric calibration ta-ble product	1.836	binary
DESIS.HSI.CTB-RAD-METADATA	DESIS-CTB_RAD-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-METADATA.xml	Processor provided metadata for radiometric calibration table prod-uct	0.003	xml
DESIS.HSI.CTB-SPE-CAL-DATA	DESIS-CTB_SPE-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-TABLE.bin	DESIS spectral calibration table product	1.836	binary
DESIS.HSI.CTB-SPE-METADATA	DESIS-CTB_SPE-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-METADATA.xml	Processor provided metadata for spectral calibration table product	0.003	xml
DESIS.HSI.CTB-DPM-CAL-DATA	DESIS-CTB_DPM-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-TABLE.bin	DESIS dead pixel calibration table product	0.229	binary
DESIS.HSI.CTB-DPM-METADATA	DESIS-CTB_DPM-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-METADATA.xml	Processor provided metadata for dead pixel calibration table product	0.003	xml

Product Type/Component	File Name	Description	Size (MiB)	Format
DESIS.HSI.CTB-LIN-CAL-DATA	DESIS-CTB_LIN-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-TABLE.bin	DESIS non-linearity correction table product	7520	binary
DESIS.HSI.CTB-LIN-METADATA	DESIS-CTB_LIN-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-METADATA.xml	Processor provided metadata for non-linearity correction table product	0.003	xml
DESIS.HSI.CTB-GEO-CAL-DATA	DESIS-CTB_GEO-CONXYZ-STARTYYMMDD_ENDYYMMDD-NNNN-TABLE.xml	DESIS geometric calibration table product	1	xml

Table 5-3 Calibration table files. Coloured rows mark the metadata files accompanying on board calibration table products.

The field XYZ in "CONXYZ" in the file name is a numeric value of 3 digits identifying the different configurations of the recording modes (X: unassigned, Y: shutter mode and Z: binning mode), see Table 5-4. Although the baseline for DESIS is that only one configuration will be used for earth observation data taking, the inclusion of this field allows the GS to be prepared to provide calibration information for all possible configurations. For details on the binning mode, refer to [AD09].

NOTE: The values for the shutter mode and the binning mode are different to the definition given in [AD10].XYZ	X: Mode of Mirror Valid for geometric calibration tables DESIS_CTB_GEO	X: Gain Mode Valid for radiometric and spectral calibration tables DESIS_CTB_SPE DESIS_CTB_RAD DESIS_CTB_LIN	Y: Shutter mode	Z: Binning mode
011	0: POI	0 HighGain 5	1: Rolling	1: binning mode 1
012	0: POI	0 HighGain 5	1: Rolling	2: binning mode 2
013	0: POI	0 HighGain 5	1: Rolling	3: binning mode 3
014	0: POI	0 HighGain 5	1: Rolling	4: binning mode 4
021	0: POI	0 HighGain 5	2: Global	1: binning mode 1
022	0: POI	0 HighGain 5	2: Global	2: binning mode 2
023	0: POI	0 HighGain 5	2: Global	3: binning mode 3
024	0: POI	0 HighGain 5	2: Global	4: binning mode 4
111	1: fail save	1 HighGain 10	1: Rolling	1: binning mode 1
112	1: fail save	1 HighGain 10	1: Rolling	2: binning mode 2
113	1: fail save	1 HighGain 10	1: Rolling	3: binning mode 3
114	1: fail save	1 HighGain 10	1: Rolling	4: binning mode 4
121	1: fail save	1 HighGain 10	2: Global	1: binning mode 1
122	1: fail save	1 HighGain 10	2: Global	2: binning mode 2
123	1: fail save	1 HighGain 10	2: Global	3: binning mode 3
124	1: fail save		2: Global	4: binning mode 4

Table 5-4 Specifier of the field XYZ in "CONXYZ" for the different configurations of the recording modes

The fields START and END in the table filenames are followed by the date with format "YYMMDD", indicating the time period for which a given calibration table is valid. In case of unknown end date (i.e., the calibration table is valid for data currently being acquired), the END date shall be "991231". Periods of validity shorter than 1 day are not considered for the calibration tables.

The field NNNN in "VNNNN" indicates a 4 digits version number for the format of the calibration table. A change of the format used in a calibration table will make it necessary to generate a new version number for that type of tables.

As an example, a valid radiometric calibration table name is:

DESIS-CTB_RAD-CON012-START180723_END991231-V0100-TABLE.bin

And for the metadata:

DESIS-CTB_RAD-CON012-START180723_END991231-V0100-METADATA.xml

5.2.2 Reference products filenames

Table 5-5 describes the product type, naming, format and size of the reference tables. The size depends on the binning mode and is calculated here for data without binning, i.e. binning mode “1”. The size of the CAL-DATA files is approximately inversely proportional to the binning factor (= binning mode).

Since the linearity table is, the number of integration times or intensity levels is assumed to be 10 steps for estimating the file size of the non-linearity correction table. The use of a linearity table depends on the laboratory measurement by the instrument team. Currently no linearity table is available.

Product Type/Component	File Name	Description	Size (MiB)	For-mat
DESIS.HSI.REF-RAD-CAL-DATA	DESIS-REF_RAD-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-TABLE.bin	DESIS radiometric reference table product	7.344	binary
DESIS.HSI.REF-RAD-METADATA	DESIS-REF_RAD-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-METADATA.xml	Processor provided metadata for radiometric reference table product	0.003	xml
DESIS.HSI.REF-SPE-CAL-DATA	DESIS-REF_SPE-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-TABLE.bin	DESIS spectral reference table product	33.05	binary
DESIS.HSI.REF-SPE-METADATA	DESIS-REF_SPE-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-METADATA.xml	Processor provided metadata for spectral reference table product	0.003	xml
DESIS.HSI.REF-LIN-CAL-DATA	DESIS-REF_LIN-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-TABLE.bin	DESIS non linearity reference table product	36.72	binary
DESIS.HSI.REF-LIN-METADATA	DESIS-REF_LIN-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-METADATA.xml	Processor provided metadata for non linearity reference table product	0.003	xml
DESIS.HSI.REF-DAR-CAL-DATA	DESIS-REF_DAR_-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-TABLE.bin	DESIS Dark current reference table product	3.672	binary
DESIS.HSI.REF-DAR-METADATA	DESIS-REF_DAR_-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-METADATA.xml	Processor provided metadata for Dark current reference table product	0.003	xml
DESIS.HSI.REF-DPM-CAL-DATA	DESIS-REF_DPM_-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-TABLE.bin	DESIS Dead pixel reference table product	0.229	binary
DESIS.HSI.REF-DPM-METADATA	DESIS-REF_DPM_-CONXYZ-STARTYYMMDD_ENDYYMMDD-VNNNN-METADATA.xml	Processor provided metadata for Dead pixel reference table product	0.003	xml

Table 5-5 Reference table files. Coloured rows mark the metadata files accompanying on board reference table products.

The details on the filenames used for Reference Tables are the same as those provided for the Calibration Tables in section 5.2.1. Details on configuration coding can be found in Table 5-4.

As an example, a valid dark current reference table name is:

DESIS-REF_DAR-CON012-START191103_END201011-V0105-TABLE.bin

And for the metadata:

DESIS-REF_DAR-CON012-START191103_END201011-V0105-TABLE.xml

5.3 Calibration and Reference Products Description and Formats

5.3.1 Calibration tables formats

In the following chapter the structure of the component DESIS.CTB-XXX-CAL-DATA is described for the different calibration modes. The files are stored as binaries.

Note that each calibration table is defined for exactly one specific configuration of the binning and shutter mode. It is not allowed to use the mixed gain setting for calibration measurements. Please see also details on configuration coding in Table 5-4.

It is highly recommended to preset the gain factors for low and high gain to an agreed default setting that is not changed during the mission to significantly reduce the number of calibration and reference tables to be updated.

Radiometric calibration format

The radiometric calibration table contains the radiometric calibration coefficients including the PRNU (photoresponse non-uniformity) for each of the *m* spatial pixels, *n* spectral channels, and each of the two gains (low gain GainL, high gain GainH). The calibration coefficients have the unit DN / (mW/cm²/sr/µm) and are stored in a table of format [m, n, 2] with single precision 4-byte float values. The numbers in brackets indicate the band number *n* and spatial pixel number *m*. The number of pixels *m* is fixed to 1024 pixels for DESIS.

Radiometric calibration coefficients in float (4 byte)				
Calibration coefficients for GainL in DN / (mW/cm²/sr/µm)N				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	CalCoeff (1, 1)	CalCoeff (1, 2)	…	CalCoeff (1, m)
Spectral Channel 2	CalCoeff (2, 1)	CalCoeff (2, 2)	…	CalCoeff (2, m)
…	…	…	…	…
Spectral Channel n	CalCoeff (n, 1)	CalCoeff (n, 2)	…	CalCoeff (n, m)
Calibration coefficients for GainH in DN / (mW/cm²/sr/µm)				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	CalCoeff (1, 1)	CalCoeff (1, 2)	…	CalCoeff (1, m)
Spectral Channel 2	CalCoeff (2, 1)	CalCoeff (2, 2)	…	CalCoeff (2, m)
…	…	…	…	…
Spectral Channel n	CalCoeff (n, 1)	CalCoeff (n, 2)	…	CalCoeff (n, m)

Table 5-6 Product file format of Radiometric calibration table

Spectral calibration table format

This spectral calibration table consists of two data sets, the central wavelengths and the full width at half maximum (FWHM) for any of the *m* spatial pixels and *n* spectral channels. The central wavelengths are the result of the spectral calibration investigation, and the FWHM is fixed because it is only characterized pre-launch. Both parameters have the unit nanometer. Central wavelengths and FWHM are stored in a table of format [m, n] with single precision 4-byte float values (see Table 5-7). The numbers in brackets indicate the band number *n* and spatial pixel number *m*.

Spectral calibration table float (4 byte)				
Central Wavelength in nm				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Central WL (1, 1)	Central WL (1, 2)	…	Central WL (1, m)
Spectral Channel 2	Central WL (2, 1)	Central WL (2, 2)	…	Central WL (2, m)
…	…	…	…	…
Spectral Channel n	Central WL (n, 1)	Center WL (n, 2)	…	Central WL (n, m)
Full Width at Half Maximum in nm				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	FWHM (1, 1)	FWHM (1, 2)	…	FWHM (1 ,m)
Spectral Channel 2	FWHM (2, 1)	FWHM (2, 2)	…	FWHM (2, m)
…	…	…	…	…
Spectral Channel n	FWHM (n, 1)	FWHM (n, 2)	…	FWHM (n, m)

Table 5-7 Product file format of Spectral calibration table file

Dead pixel calibration mask format

All calibration measurements are used to check the permanent functionality of the pixels. This information is stored in the Dead pixel mask (DPM). The first calibration table is performed before launch. If any further analysis finds new corrupted pixels, the DPM reference will be updated, stored and finally provided as a new calibration table. The following types of dead pixels are discriminated:

- Cold pixel: it produces no response signal and remains dark independent of the illumination level
- Hot pixel: its output signal appears permanently bright or saturated, even with low radiance input, i.e. dark current to dark water reflectance level
- Stuck pixel: its output signal does not change at different illumination levels
- Flickering pixel: its response does not correlate with the input signal, that means stochastically varying output at constant illumination

The characteristic of each pixel on the focal plane is coded in one byte as shown in Table 5-8.

Bit number	Pixel failure, if bit set
0	Dead pixel
1	cold pixel
2	hot pixel
3	stuck pixel
4	flickering pixel
5	Manufacturing defect
6	Unreliable calibrated pixel
7	Un used

Table 5-8 Bit coding of pixel failures in the Dead pixel mask

Table 5-9 shows the format of the Dead pixel calibration mask. The numbers in brackets indicate the band number *n* and spatial pixel number *m*. All valid pixels have a value equal to 0. If the most significant bit is set, the pixel is dead, i.e. invalid.

Dead pixel mask in byte (1 byte)				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Status (1, 1)	Status (1, 2)	…	Status (1, m)
Spectral Channel 2	Status (2, 1)	Status (2, 2)	…	Status (2, m)
…	…	…	…	…
Spectral Channel n	Status (n, 1)	Status (n, 2)	…	Status (n, m)

Table 5-9 Product file format of the Dead pixel calibration mask

Non-linearity correction table format

This look-up-table for the non-linearity correction is obtained as the result of investigations of linearity calibration measurements. For each digital number DN ranging from 0 to 2^{14}-1, the corrected value DNcorr(m, n) for each pixel *m* of each channel *n* is given as an unsigned short integer value of 2 bytes. (see Table 5-10). The gain is coded in the highest bit, i.e. 0 represents the low gain and 1 the high gain.

Non-linear correction values in unsigned short (2 byte)	
DN	**DN^{corr} (m, n)**
0	DNcorr_0(m, n)
1	DNcorr_1(m, n)
2	DNcorr_2(m, n)
…	...
2^14-1	DNcorr_16383(m, n)

Table 5-10 Product file format of the Non-linearity correction table

5.3.2 Reference tables formats

This section describes the format of the binary DESIS reference tables. These tables are statistics of the corresponding calibration measurements and serve as a nominal reference for validation of the next calibration measurement. Since most reference files contain data sets for low and high gains, the gains must be preset to an agreed default setting that is not changed during the mission.

Note that each reference table is defined for exactly one specific configuration of the binning and shutter mode. It is not allowed to use the mixed gain setting for calibration measurements. Please see also details on configuration coding in Table 5-4.

Radiometric reference table format

The radiometric reference table is calculated from a valid radiometric calibration measurement for a specific setting of low and high gain combination, binning and shutter mode. A reference table contains the statistics for the two low and the two high gain measurement cycles. Two intensity settings are defined for each of the two gains, which means that four illuminated sessions are defined in a radiometric calibration sequence. Once defined, the intensities should not be changed to ensure continious and meaningful observation of the radiometric references. Each statistical data set consists of the mean and the standard deviation for each sensor pixel. The numbers in brackets indicate the band number *n* and spatial pixel number *m*. Possibly dead pixels are not masked. The data are stored as 4 byte float values (see Table 5-11).

Radiometric reference values in float (4 byte)				
Statistical values for low gain @ intensity 1				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
…	…	…	…	…
Spectral Channel n	Mean (n, 1)	Mean (n, 2)	…	Mean (n, m)
Spectral Channel 1	StdDeviation (1, 1)	StdDeviation (1, 2)	…	StdDeviation (1, m)
…	…	…	…	…
Spectral Channel n	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
Statistical values for low gain @ intensity 2				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
…	…	…	…	…
Spectral Channel n	Mean (n, 1)	Mean (n, 2)	…	Mean (n, m)
Spectral Channel 1	StdDeviation (1, 1)	StdDeviation (1, 2)	…	StdDeviation (1, m)
…	…	…	…	…
Spectral Channel n	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
Statistical values for high gain @ intensity 1				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
…	…	…	…	…
Spectral Channel n	Mean (n, 1)	Mean (n, 2)	…	Mean (n, m)
Spectral Channel 1	StdDeviation (1, 1)	StdDeviation (1, 2)	…	StdDeviation (1, m)
…	…	…	…	…
Spectral Channel n	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
Statistical values for high gain @ intensity 2				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
…	…	…	…	…
Spectral Channel n	Mean (n, 1)	Mean (n, 2)	…	Mean (n, m)
Spectral Channel 1	StdDeviation (1, 1)	StdDeviation (1, 2)	…	StdDeviation (1, m)
…	…	…	…	…
Spectral Channel n	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)

Table 5-11 Product file format of Radiometric reference table

Spectral reference table format

The spectral reference table is calculated from a valid spectral calibration measurement for a specific setting of low and high gain combination, binning and shutter mode. A reference table contains the statistics for the nine illuminated sessions of each LED types for each of the low and the high gain measurement cycles. The intensities are specially adjusted for each LED and should be maintained throughout the entire mission operating time. Each statistical data set consists of the mean and the

standard deviation for each sensor pixel. The numbers in brackets indicate the band number *n* and spatial pixel number *m*. Possibly dead pixels are not masked. The data are stored as 4 byte float values (see Table 5-12).

Spectral reference values in float (4 byte)				
LED 1: statistical values for low gain				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
…	…	…	…	…
Spectral Channel n	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
Spectral Channel 1	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
…	…	…	…	…
Spectral Channel n	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
repeated for LED 2 to LED 8: statistical data sets for low gain				
LED 9: statistical values for low gain				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
…	…	…	…	…
Spectral Channel n	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
Spectral Channel 1	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
…	…	…	…	…
Spectral Channel n	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
LED 1: statistical values for high gain				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
…	…	…	…	…
Spectral Channel n	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
Spectral Channel 1	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
…	…	…	…	…
Spectral Channel n	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
repeated for LED 2 to LED 8: statistical data sets for high gain				
LED 9: statistical values for high gain				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
…	…	…	…	…
Spectral Channel n	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
Spectral Channel 1	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
…	…	…	…	…
Spectral Channel n	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)

Table 5-12 Product file format of Spectral reference table

Linearity reference table format

The linearity reference table is calculated from a valid linearity calibration measurement for a specific setting of low and high gain combination, binning and shutter mode. A reference table contains the statistics for the low and the high gain measurement cycles. Each statistical data set consists of the mean and the standard deviation for each sensor pixel for all integration times or illumination levels [TBD14]. The number of integration times or illumination levels is referred to as step, counting from 1 to *k*. Possibly dead pixels are not masked. The data are stored as 4 byte float values (see Table 5-13). The numbers in brackets indicate the band number *n* and spatial pixel number *m*.

Linearity reference values in float (4 byte)				
Statistic values for low gain, all integration times or illumination levels k				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean_Step_1 (1, 1)	Mean_Step_1 (1, 2)	…	Mean_Step_1 (1, m)
…	…	…	…	…
Spectral Channel 1	Mean_Step_k (1, 1)	Mean_Step_k (1, 2)	…	Mean_Step_k (1, m)
…	…	…	…	…
…	…	…	…	…
Spectral Channel n	Mean_Step_1 (n, 1)	Mean_Step_1 (n, 2)	…	Mean_Step_1 (n, m)
…	…	…	…	…
Spectral Channel n	Mean_Step_k (n, 1)	Mean_Step_k (n, 2)	…	Mean_Step_k (n, m)
Spectral Channel 1	StdDev_Step_1 (1, 1)	StdDev_Step_1 (1, 2)	…	StdDev_Step_1 (1, m)
…	…	…	…	…
Spectral Channel 1	StdDev_Step_k (1, 1)	StdDev_Step_k (1, 2)	…	StdDev_Step_k (1, m)
…	…	…	…	…
…	…	…	…	…
Spectral Channel n	StdDev_Step_1 (n, 1)	StdDev_Step_1 (n, 2)	…	StdDev_Step_1 (n, m)
…	…	…	…	…
Spectral Channel n	StdDev_Step_k (n, 1)	StdDev_Step_k (n, 2)	…	StdDev_Step_k (n, m)
Statistic values for high gain, all integration times or illumination levels k				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean_Step_1 (1, 1)	Mean_Step_1 (1, 2)	…	Mean_Step_1 (1, m)
…	…	…	…	…
Spectral Channel 1	Mean_Step_k (1, 1)	Mean_Step_k (1, 2)	…	Mean_Step_k (1, m)
…	…	…	…	…
…	…	…	…	…
Spectral Channel n	Mean_Step_1 (n, 1)	Mean_Step_1 (n, 2)	…	Mean_Step_1 (n, m)
…	…	…	…	…
Spectral Channel n	Mean_Step_k (n, 1)	Mean_Step_k (n, 2)	…	Mean_Step_k (n, m)
Spectral Channel 1	StdDev_Step_1 (1, 1)	StdDev_Step_1 (1, 2)	…	StdDev_Step_1 (1, m)
…	…	…	…	…
Spectral Channel 1	StdDev_Step_k (1, 1)	StdDev_Step_k (1, 2)	…	StdDev_Step_k (1, m)
…	…	…	…	…
…	…	…	…	…
Spectral Channel n	StdDev_Step_1 (n, 1)	StdDev_Step_1 (n, 2)	…	StdDev_Step_1 (n, m)

Linearity reference values in float (4 byte)				
…	…	…	…	…
Spectral Channel n	StdDev_Step_k (n, 1)	StdDev_Step_k (n, 2)	…	StdDev_Step_k (n, m)

Table 5-13 Product file format of Linearity reference table

Dark current reference table format

The dark current reference table has no corresponding calibration table, since for the complete calibration procedure the current dark current measurements are used before and/or after each data recording. The dark current reference table is used to check the current dark values and furthermore for monitoring and quality control purposes. The table first contains dark current values measured during the pre-launch instrument calibration and characterization campaign, which are replaced in orbit by on-board dark calibration values. Each statistical data set consists of the mean and the standard deviation for each sensor pixel (see Table 5-14). The numbers in brackets indicate the band number *n* and spatial pixel number *m*. Possibly dead pixels are not masked.

Dark current reference values in float (4 byte)				
Statistical values for low gain				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
…	…	…	…	…
Spectral Channel n	Mean (n, 1)	Mean (n, 2)	…	Mean (n, m)
Spectral Channel 1	StdDeviation (1, 1)	StdDeviation (1, 2)	…	StdDeviation (1, m)
…	…	…	…	…
Spectral Channel n	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)
Statistical values for high gain				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Mean (1, 1)	Mean (1, 2)	…	Mean (1, m)
…	…	…	…	…
Spectral Channel n	Mean (n, 1)	Mean (n, 2)	…	Mean (n, m)
Spectral Channel 1	StdDeviation (1, 1)	StdDeviation (1, 2)	…	StdDeviation (1, m)
…	…	…	…	…
Spectral Channel n	StdDeviation (n, 1)	StdDeviation (n, 2)	…	StdDeviation (n, m)

Table 5-14 Product file format of Dark current reference table

Dead pixel reference mask format

Changes in the performance and behaviour of the individual sensor detectors are to be expected during operation of the DESIS instrument. Such changes can occur gradually or suddenly. Therefore, each of the calibration measurements is used to analyze the permanent functionality of the pixels. The dead pixel reference mask serves as container for the verification process. Since one measurement alone is not sufficient to confirm that a pixel is limited or damaged in its functionality, the abnormal behaving pixel is marked with a suspicious flag. After verification by at least one further calibration measurement, the pixel is finally marked as dead and a new DPM calibration table is released. The first reference is performed before launch. Table 5-15 shows the bit coding of the DPM reference table (16 bit unsigned byte).

Bit number	Pixel failure, if bit is set
0	dead / invalid pixel

1	cold pixel
2	hot pixel
3	stuck pixel
4	flickering pixel
5	Manufacturing defects
6	Unreliable calibrated pixel
7	suspicious, found in dark measurement
8	suspicious, found in radiometric calibration
9	suspicious, found in spectral calibration
10…15	Not used

Table 5-15 Bit coding in the Dead pixel reference

The format of the Dead pixel reference mask is shown in Table 5-16. The numbers in brackets indicate the band number *n* and spatial pixel number *m*.

Dead pixel mask reference table in byte (1 byte)				
	Pixel 1	Pixel 2	…	Pixel m
Spectral Channel 1	Status (1, 1)	Status (1, 2)	…	Status (1, m)
Spectral Channel 2	Status (2, 1)	Status (2, 2)	…	Status (2, m)
…	…	…	…	…
Spectral Channel n	Status (n, 1)	Status (n, 2)	…	Status (n, m)

Table 5-16 Product file format of Dead pixel reference mask

5.3.3 Geometric Calibration Table format

The geometric calibration values are provided in a xml structure, which is extracted and explained in section 8.1 and consists of

- periodically updated boresight angles (tag: <boresightAngles>)
- constant POI mounting angles (<deltaOmegaX> and <deltaOmegaZ> as described in [AD05])
- interior orientation consisting of laboratory measurements at selected pixel positions for each band

Example of a geometric Calibration Table file:

```
<?xml version="1.0" encoding="UTF-8"?>
<calGeom>
    <deltaOmegaFM>0.01</deltaOmegaFM>
    <deltaPhiFM>0.12</deltaPhiFM>
    <betaFM>-160.0</betaFM>
    <deltaOmegaPOI>0.01</deltaOmegaPOI>
    <deltaPhiPOI>0.12</deltaPhiPOI>
    <betaPOI>20.0</betaPOI>
    <boresightAngles>
        <RotX>0.02001</RotX>
        <RotY>0.01004</RotY>
        <RotZ>0.30322</RotZ>
    </boresightAngles>
```

<interiorOrientation>
<band>
<bandNumber>1</bandNumber>
<calAngles>
<pixelNumber>0</pixelNumber>
<phiX>0.0001</phiX>
<phiY>-4.000</phiY>
</calAngles>
<calAngles>
<pixelNumber>150</pixelNumber>
<phiX>0.0001</phiX>
<phiY>-2.000</phiY>
</calAngles>
<calAngles>
<pixelNumber>300</pixelNumber>
<phiX>0.0001</phiX>
<phiY>0.000</phiY>
</calAngles>
<calAngles>
<pixelNumber>500</pixelNumber>
<phiX>0.0001</phiX>
<phiY>0.000</phiY>
</calAngles>
<calAngles>
<pixelNumber>700</pixelNumber>
<phiX>0.0001</phiX>
<phiY>3.000</phiY>
</calAngles>
</band>
<band>
<bandNumber>2</bandNumber>
<calAngles>
<pixelNumber>0</pixelNumber>
<phiX>0.0001</phiX>
<phiY>-4.000</phiY>
</calAngles>
<calAngles>
<pixelNumber>150</pixelNumber>
<phiX>0.0001</phiX>
<phiY>-2.000</phiY>
</calAngles>
<calAngles>
<pixelNumber>300</pixelNumber>
<phiX>0.0001</phiX>

```
                <phiY>0.000</phiY>
            </calAngles>
            <calAngles>
                <pixelNumber>500</pixelNumber>
                <phiX>0.0001</phiX>
                <phiY>0.000</phiY>
            </calAngles>
            <calAngles>
                <pixelNumber>700</pixelNumber>
                <phiX>0.0001</phiX>
                <phiY>3.000</phiY>
            </calAngles>
        </band>
    </interiorOrientation>
</calGeom>
```

5.4 Reference Information for Calibration and Reference Table Metadata Files

5.4.1 Metadata Cards

The metadata file for the calibration and reference tables contains information about the calibration measurements from which it is derived. Therefore, the metadata file contains reference information such as time, date, orbit and other parameters from the corresponding calibration product.

Each metadata file consists of 3 information blocks:

- metadata file information
- base parameters
- specific parameters

Parameter	List of sub-elements	Value Range	Remarks	Availability	
				CTB	REF
ctb_ref	metadata base specific		Root of xml doc	X	X
metadata	name comment copyright license		Type: structure General information about the metadata file itself and copyright notice	X	X
name		DESIS-<ctbref_type>-CON<XYZ>-START<yymmdd>_END<yymmss>-V<version>_METADATA.xml	Type: string Name of the metadata file of the calibration or reference table product <ctbref_type> = {CTB_RAD, CTB_SPE, CTB_LIN, CTB_DPM, REF_RAD, REF_SPE, REF_LIN, REF_DPM, REF_DAR} <XYZ> with: X = 0 (unused), Y = {0, 1} for global shutter or rolling shutter = 1, Z = {1, 2, 3, 4} for binning mode, unbinned = 1 <yymmdd> = date (year, month, day) <version> = NNNN, 4 digit version number	X	X

Parameter	List of sub-elements	Value Range	Remarks	Availability	
			Example: DESIS-CTB_RAD-CON011-START180901_END991231-V0100-METADATA.xml		
comment			Type: string Free text field	X	X
copyright		DLR	Type: string Copyright information	X	X
license		DLR internal usage	Type: string Constant value	X	X
base	version dataVersion revision sphere size level productType format temporalCoverage		Type: structure Contains basic information about the data (e.g. time, calibration or reference table type)		
version		{nn.nn}	Type: string Global Version of the calibration processing chain	X	X
dataVersion		[0,...,-]	Type: unsigned int 32 bit Version of housekeeping data in the raw files	X	X
revision		{nn.nn}	Type: string Version of the calibration processor being executed	X	X
sphere		{earth, none}	Type: string Should be always ‘none’ for calibration or reference tables	X	X
size		[0,…,-]	Type: non-negative integer Size of product in MiB of the unzipped product.	X	X

Parameter	List of sub-elements	Value Range	Remarks	Availability	
level		{CAL, REF}	Type: string Product level	X	X
productType			Type: string Identifies the product type (e.g. Radiometric Calibration Table, Spectral Reference Table, Dark Reference Table...)	X	X
format		{bin, gz, tar, tgz, xml}	Type: string Format of the product	X	X
temporalCoverage	startTime endTime		Type: structure Contains the acquisition time (UTC) of the first and the last scan line of the original calibration data take. For an acquisition with rolling shutter, the time is related to first channel of the image.	X	X
startTime		2018-09-15T01:45:11.123456Z	Type: dateTime Start time is the time of first scan line in UTC	X	X
endTime		2018-09-15T01:45:11.123456Z	Type: dateTime End time is the time of last scan line in UTC	X	X
specific	mission satelliteID sensor sensorMaxBands acquisitionMode tableVersion tableCode validityStartDateTime processingDateTime processingCenter processingNode missionPhase numberOfSpatialPixels numberOfBands sensorTotalBands		Type: structure Contains specific information about table properties.	X	X

Parameter	List of sub-elements	Value Range	Remarks	Availability	
	lineNumberTop lineNumberBottom firstLine lastLine binningMode framePeriod autoGainThreshold integrationTime refTemperature orbitDirection orbitType lowGainFactor highGainFactor configFPA pointingMirrorAngle originData				
mission		DESIS	Type: string Mission name is constant.	X	X
satelliteID		ISS	Type: string Satellite identifier is constant.	X	X
sensor		HSI	Type: string Sensor name is constant.	X	X
sensorTotalBands		[1-235]	Type:integer The maximum number of used spectral bands, ideally constant as 235 along all the mission.	X	X
acquisitionMode		{image_strip_mode, image_stereo_mode, forward_motion_compensation_mode, radiometric_calibration_mode, spectral_calibration_mode, dark_calibration_mode,	Type: string Defines the acquisition mode. The modes *image_strip_mode*, *image_stereo_mode*, and *forward_motion_compensation_mode* are earth imaging modes, from which only dark measurement values (before, after) are used to create	X	X

Parameter	List of sub-elements	Value Range	Remarks	Availability	
		general_calibration_mode}	corresponding dark calibration/reference tables.		
tableVersion		{nn.nn}	Type: string Version number of the calibration or reference table.	X	X
tableCode		{CTB_RAD, CTB_SPE, CTB_LIN, CTB_DPM, REF_RAD, REF_SPE, REF_LIN, REF_DAR, REF_DPM}	Type: string Identifies the table type.	X	X
validityStartDateTime		2018-09-01T00:26:11.123456Z	Type: dateTime Validity start date and time of the CTB/REF table in UTC	X	X
processingDateTime		2018-09-15T01:45:11.123456Z	Type: dateTime Processing date and time in UTC.	X	X
processingCenter		{NZ, OP,TBE}	Type: string Name of processing center OP = DLR@Oberpfaffenhofen and NZ = DLR@Neustrelitz TBE = Teledyne	X	X
processingNode			Type: string Provided by command ‘hostname’.	X	X
missionPhase		{pre-launch, leop, commissioning, routine}	Type: string Mission phase where the datatake is acquired.	X	X
numberOfSpatialPixels		[1...1024]	Type: integer Th number of spatial sensor pixels should be a constant value of 1024.	X	X
numberOfBands		[1...235]	Type: integer The number of used spectral bands.	X	X
sensorTotalBands		256	Type: integer	X	X

Parameter	List of sub-elements	Value Range	Remarks	Availability	
			Maximum number of spectral bands (physical dimension of the sensor).		
lineNumberTop		[0,...,128]	Type: integer Number of active spectral lines in the top part of the focal plane array.	X	X
lineNumberBottom		[0,...,128]	Type: integer Number of active spectral lines in the bottom part of the focal plane array.	X	X
firstLine		[0...255]	Type: unsigned int 8 bit First selected sensor band.	X	X
lastLine		[0...255]	Type: unsigned int 8 bit Last selected sensor band.	X	X
binningMode		{1, 2, 3, 4}	Type: unsigned int 8 bit Binning mode of the table. If binningMode is greater than 1, two or more spectral lines are combined to one channel or band. For details see [AD09].	X	X
framePeriod		[0,…,-]	Type: integer Frame period in units of 32 microseconds.	X	X
autoGainThreshold		[0,…,65535]	Type: unsigned int 16 bit Threshold for auto-gain setting.	X	X
integrationTime		[0,…,-]	Type: integer Integration time in units of 32 microseconds.	X	X
refTemperature	attribute: units		Type: float Reference temperature for the data set as floating-point value Attribute: *units* for the physical unit (“K” for Kelvin or “degC” for degree Celsius)	X	X
orbitDirection		{ASCENDING, DESCENDING}	Type: string Ascending or descending mean orbit direction for the data take	X	X
orbitType		{predicted, precision, none}	Type: string Defines the orbit type	X	X
lowGainFactor		{1, 2}	Type:integer	X	X

Parameter	List of sub-elements	Value Range	Remarks	Availability	
			Gain setting of the sensor for low gain		
highGainFactor		{5, 10}	Type:integer Gain setting of the sensor for high gain	X	X
configFPA		{rolling_shutter, global_shutter}	Type: string Shutter mode of the focal plane array.	X	X
pointingMirrorAngle		[-15,…,114]	Type: double Angle of the pointing mirror measured in decimal degree. Forward looking is positive and backward looking is negative. The angle of the calibration position is 114 degrees.	X	X
originData	originCalData originDarkBefore originDarkAfter		Type: structure Contains information about the original data, from which the present CTB/REF table has been calculated.	X	X
originCalData	originName requestID datatakeID imageID		Type: structure Information about the used original calibration measurement.	X	X
originName			Type: string Original file name	X	X
requestID			Type: string Unique request identifier of the original data file generated by TBE.	X	X
datatakeID		[0000000001…9999999999]	Type: string (10 digits) The unique data take identifier is copied from of the original data file. Example: 1023456789	X	X
imageID		[0000000001001...999999999999]	Type: string (13 digits) The unique image identifier is copied from the original data file. Example: 1023456789003	X	X
originDarkBefore	originName		Type: structure	X	X

Parameter	List of sub-elements	Value Range	Remarks	Availability	
	requestID datatakeID imageID		Information about the used original dark calibration measurement before a data take. See description of the *originCalData* above for details on elements.		
originDarkAfter	originName requestID datatakeID imageID		Type: structure Information about the used original dark calibration measurement after a data take. See description of the *originCalData* above for details on elements.	X	X

Table 5-17 Metadata for calibration and reference tables

5.4.2 Example of Metadata file

```
<?xml version="1.0" encoding="UTF-8"?>
<ctb_ref xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="DESIS_schema_CTB-REF.xsd">
	<metadata>
		<name>DESIS-CTB_RAD-CON011-START180420_END991231-V0100-
METADATA.xml</name>
	<comment>Example Metadata of Radiometric Calibration File</comment>
	<copyright>DLR</copyright>
	<license>DLR internal usage</license>
	</metadata>
	<base>
		<version>01.00</version>
		<dataVersion>1</dataVersion>
		<revision>01.00</revision>
		<sphere>none</sphere>
		<size>1.836</size>
		<level>CAL</level>
		<productType>Radiometric Calibration Table</productType>
		<format>bin</format>
		<temporalCoverage>
			<startTime>2018-04-20T09:26:12</startTime>
			<endTime>2018-04-20T09:30:47</endTime>
		</temporalCoverage>
	</base>
	<specific>
		<mission>DESIS</mission>
		<satelliteID>ISS</satelliteID>
		<sensor>HSI</sensor>
		<sensorMaxBands>235</sensorMaxBands>
		<acquisitionMode>radiometric_calibration_mode</acquisitionMode>
		<tableVersion>01.00</tableVersion>
		<tableCode>CTB_RAD</tableCode>
		<validityStartDateTime>2018-04-20T12:00:00</validityStartDateTime>
		<processingDateTime>2018-04-20T12:00:00</processingDateTime>
		<processingCenter>OP</processingCenter>
		<processingNode>zeus.af.op.dlr.de</processingNode>
		<missionPhase>pre-launch</missionPhase>
		<numberOfSpatialPixels>1024</numberOfSpatialPixels>
		<numberOfBands>235</numberOfBands>
		<sensorTotalBands>256</sensorTotalBands>
		<lineNumberTop>117</lineNumberTop>
		<lineNumberBottom>118</lineNumberBottom>
		<firstLine>11</firstLine>
		<lastLine>245</lastLine>
		<binningMode>1</binningMode>
		<framePeriod>118</framePeriod>
		<autoGainThreshold>4000</autoGainThreshold>
		<integrationTime>118</integrationTime>
		<refTemperature units="degC">21.3</refTemperature>
	<orbitDirection>ASCENDING</orbitDirection>
	<orbitType>predicted</orbitType>
	<lowGainFactor>2</lowGainFactor>
```

```
      <highGainFactor>10</highGainFactor>
      <configFPA>rolling_shutter</configFPA>
      <pointingMirrorAngle>114.0</pointingMirrorAngle>
      <originData>
            <originCalData>
                  <originName>DESIS-HSI-DC-DT0000010030_001-180420T092612-
V0100_METADATA.xml</originName>
                  <requestID>12345</requestID>
                  <datatakeID>0000010031</datatakeID>
                  <imageID>0000010031001</imageID>
            </originCalData>
            <originDarkBefore>
                  <originName>DESIS-HSI-DC-DT0000010030_001-180420T092612-
V0100_METADATA.xml</originName>
                  <requestID>12345</requestID>
                  <datatakeID>0000010031</datatakeID>
                  <imageID>0000010031001</imageID>
            </originDarkBefore>
            <originDarkAfter>
                  <originName>DESIS-HSI-DC-DT0000010030_001-180420T092612-
V0100_METADATA.xml</originName>
                  <requestID>12345</requestID>
                  <datatakeID>0000010031</datatakeID>
                  <imageID>0000010031001</imageID>
            </originDarkAfter>
      </originData>
      </specific>
</ctb_ref>
```

6. Reference Information for L1A/L1B Auxiliary Data

TBE will provide DLR with all the auxiliary data needed for data processing. The details on filenames and formats are defined in [AD11]. The details on the time synchronisation and rolling shutter mode including mapping between detector lines and the acquisition time is defined in documents [AD06] and [AD07] provided by DLR OS.

7. Reference Information for L1A Metadata

7.1 Metadata Cards

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
hsi_doc	Metadata Base specific		Root node	X	x	x	x	x
metadata	name comment copyright license		General information about the metadata file itself and copyright notice	X	x	x	x	x
name		DESIS-<product_type>-DT<datatake_ID>_<tile_ID>-<yyyymmdd>T<hhmmss>-<version>_METADATA.xml	Type: string Name of the product metadata file	X	x	x	x	x
comment			Type: string Free text field	X	x	x	x	x
copyright		DLR, TBE	Type: string Copyright information	X	x	x	x	x
license		Example DLR internal usage	Type: string	X	x	x	x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
base	version dataVersion revision sphere size level format spatialCoverage altitudeCoverage temporalCoverage		Contains basic information about the data (e.g. location, time, processing level)		x	x	x	x
version		{nn.nn}	Type: string Global Version/Revision of the processing chain	X	x	x	x	x
dataVersion		[0,…-]	Type: unsigned int 32 bit Version of housekeeping data in the raw files		x	x	x	x
sphere		{earth, none}	Type: string Should be earth always for DESIS products. None, if no sphere is scannned e.g. deep space, internal lamps, calibration, dark current,…	X	x	x	x	x
size		[0,…,-]	Type: float Size of product in MB (in units of 1048576 Bytes) of the unzipped product	X	x	x	x	x
level		{L1A, S1A, DC, CAL}	Type: string	X	x	x	x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
			Product Level: L1A: Earth image data S1A: experimental products DC: Dark current measurements CAL: calibration measurements					
format		{bil}	Type: string Image data format (currently this is Band-Interleaved-by-Line BIL)	X	x	x	x	x
spatialCoverage	boundingPolygon		Contains information on the spatial coverage of the product given w.r.t. the WGS84 geodatic datum	X			x	x
boundingPolygon	point		The bounding polygon is a list of points starting with the most starboard pixel of the first scanline and followed by counter-clockwise sequence of four points, whereas the last point is identical with the first point. See 8.3.3	X			x	x
point	frame latitude longitude		Type: string (for frame) The frame can be an element from {center, point_1, point_2, point_3, point_4, point_5} Type: double (for latitude and longitude) longitude can be [-180° west of Greenwich,…,+180 east of Greenwich] latitude can be [-90° south of equator,…,+90° north of equator]	X			x	x
altitudeCoverage			Type: double Mean platform height above WGS84 ellipsoid during data aquisition	X			x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
temporalCoverage	startTime endTime		Contains the time of the first scanline acquistion and the last scanline acquistion given in UTC		x	x	x	x
startTime endTime		2013-04-15 T01:45:11.123456Z	Type: string startTime: time of first scanline in UTC (e.g. 2017-04-15T01:45:11.123456Z) endTime: time of last scanline in UTC (e.g. 2017-04-15T01:46:05.123456Z) For an acquistion with rolling shutter, the time is related to first channel of the image.	X	x	x	x	x
specific	mission satelliteID sensor sensorMaxBands acquisitionMode requestID datatakeID imageID tileID numberOfTiles numberOfBands pixelSizeAlong pixelSizeAcross widthOfScene			X	x	x	x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
	heightOfScene missionPhase orbitDirection orbitType processingDateTime processingCenter processingNode processible sunAzimuthAngle sunZenithAngle sceneAzimuthAngle sceneIncidenceAngle lowGainFactor highGainFactor lineNumberTop lineNumberBottom firstLine lastLine binningMode framePeriod autoGainThreshold integrationTime configFPA							

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
	pointingMirrorAngle qualitiyIndicator							
mission		DESIS	Type: string Mission name is constant	X	x	x	x	x
satelliteID		ISS	Type: string Satellite is constant	X	x	x	x	x
sensor		HSI	Type: string Sensor type is constant	X	x	x	x	x
sensorMaxBands		[0-235]	Type:integer Ideally constant as 235 along all the mission.	X	x	x	x	x
acquisitionMode		{image_strip_mode, image_stereo_mode, forward_motion_compensation_mode, spectral_calibration_mode, radiometric_calibration_mode, DSNU_calibration_mode, PRNU_calibration_mode, linearity_calibration_mode_by_integration_time, linearity_calibration_mode_by_intensity, geometry_calibration_mode, technology_mode }	Type: string See [AD03]	X	x	x	x	x
requestID			Type: string	X	x	x	x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
			Unique request identifier generated by TBE					
datatakeID		[0000000001,…,9999999999]	Type: string (10 digits) Unique datatake ID. Example: 1234567890	X	x	x	x	x
imageID		[0000000001001,…,99999999999]	Type: string (13 digits) The unique imageID is composed of the datatakeID and the tileID by imageID = string(datatakeID)+string(tileID) Example: 1234567890003	X	x	x	x	x
tileID		[001,…,999]	Type: string (3 digits) Tile number within a datatake increasing timely starting from 001. This is also valid for DC and CAL products. Example: 003	X	x	x	x	x
numberOfTiles		[1,…999]	Type: integer Number of tiles in the datatake of the same product class	X	x	x	x	x
numberOfBands		[1,…,235]	Type: integer Number of spectral channels of the tile	X	x	x	x	x
pixelSizeAlong		30	Type: float This element has an attribute (unit = M for meter which defines the resolution of the pixel in along track direction	X			x	x
pixelSizeAcross		30	Type: float	X			x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
			This element has an attribute (unit = M for meter and unit = D for decimal degree) which defines the resolution of the pixel in across diirection.					
widthOfScene		1024	Type: integer Number of spectral pixels in a scanline (across direction)	X	x	x	x	x
heightOfScene		1040	Type: integer Number of pixels in along track direction. This contains 8 additional lines befor and 8 additional after the tile. The Virtual Channel contains only information of 1024 frames (without additional lines).	X	x	x	x	x
missionPhase		{pre-launch, leop, commissioning, routine}	Type: string Mission phase where the datatake is acquired	X	x	x	x	x
orbitDirection		{ASCENDING, DESCENDING}	Type: string Ascending or descending mean orbit direction within a tile	X			x	x
orbitType		{predicted, precision, none}	Type: string Defines the orbit type None - not provided				x	x
processingDateTime		2013-04-15 T01:45:11.123456Z	Type: string Processing date and time in UTC	X	x	x	x	x
processingCenter		{NZ, OP, TBE}	Type: string	X	x	x	x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
			Name of processing center OP = DLR@Oberpfaffenhofen and NZ = DLR@Neustrelitz TBE = Teledeyne Brown Engineering					
processingNode			Type: string Provided by command 'hostname'	X	x	x	x	x
processible		{-1,0,1}	Type: integer Specifies if the data is processible (value 1) or not processible (value 0) or processible with reduced quality (suspicious) (value -1)	X	x	x	x	x
sunAzimuthAngle		[0,…360]	Type: double The value is derived at the scene center and counted positive from north clockwise. The value is given in decimal degree.	X			x	x
sunZenithAngle		[0,…90]	Type: double This element has an attribute (DEG) which defines the unit of the displayed value. The value is derived w.r.t. WGS84 at the center of scene. Value is set to 90.0 in case the sun is not visible	X			x	x
sceneAzimuthAngle		[0,…,360]	Type: double For L1A (see **Fehler! Verweisquelle konnte nicht gefunden werden.**) The value is derived from the mean path w.r.t. north direction and counted positive clockwise. The value is given in decimal degree. Note: meaning changes for different product	X			x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
			levels changes					
sceneIncidenceAngle		[0,…,90]	Type: double The angle between normal at the scene center and the lock direction of the sensor. The value is given in decimal degree.	X			x	x
lowGainFactor		{1,2}	Type:integer Gain setting of the sensor for low gain	X	x	x	x	x
highGainFactor		{1,2,5,10}	Type:integer Gain setting of the sensor for high gain	X	x	x	x	x
lineNumberTop		[0,…,128]	Type: integer Number of active spectral lines in the top part of the focal plane array		x	x	x	x
lineNumberBottom		[0,…,128]	Type: integer Number of active spectral lines in the bottom part of the focal plane array		x	x	x	x
firstLine		[0,…,256]	Type: Integer Number of first line on FPA focal plane		x	x	x	x
lastLine		[0,…,256]	Type: Integer Number of last line on FPA focal plane		x	x	x	x
binningMode		[1,2,3,4]	Type: integer Binning of of acquisition		x	x	x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
framePeriod		[0,…,-]	Type: integer Frame period in units of 32 usec		x	x	x	x
autoGainThreshold		[0,…,65535]	Type: integer Threshold for autogain setting		x	x	x	x
integrationTime		[0,…,-]	Type: integer Integration time in units of 32 usec		x	x	x	x
configFPA		{rolling_shutter, global_shutter}	Type: string Shutter mode of the focal plane array	X	x	x	x	x
pointingMirrorAngle		[-8.5,…,8.5]	Type: double Angle of the pointing mirror measured in decimal degrees. Forward is positive while backward is negative. For DC and CAL products there is not restriction on the angle. For FMC products the starting angle is provided In case of fail save the angle -0.0 is written and different geometric calibration tables will be used according to the mounting of the second fixed mirror. The value “-0.0” should be checked on a string basis.	X	x	x	x	x
qualityIndicator	screeningStatus screeningResult		Type: structure; required Includes the screening results of housekeeping parameters in the virtual channel and the quality	X	x	x	x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
	darkBeforeQuality darkAfterQuality		of the dark current measurements					
screeningStatus		{-1,0,1}	Type: integer; required Screening result status can be a WARNING (-1), an ERROR (0), or FAULTLESS (1)	X	x	x	x	x
screeningResult	parameter		Type: structure; required, one or more sets Container for one tested housekeeping parameter in the virtual channel		x	x	x	x
parameter	status name type description info value units		Type: structure Information about a tested physical or (device or command) status parameter, includes description of properties and test results		x	x	x	x
status		{-1, 0, 1}	Type: integer; required Test status: WARNING = -1, ERROR = 0, FAULTLESS = 1		x	x	x	x
name			Type: string; required Unique name code of the parameter		x	x	x	x
type		{temperature, voltage, current, power, status}	Type: string; required Predefined parameter type description, list can		x	x	x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
			be extended					
description			Type: string; optional Human readable parameter description as free text		x	x	x	x
info			Type: string; optional Information in case of failure or limit violation		x	x	x	x
value			Type: string; required one value or a list of values, separated by comma or space		x	x	x	x
units			Type: string; optional Physical unit of <value> or '1'		x	x	x	x
darkBeforeQuality	available status		Type: structure; required Contains screening results of dark current measurements before datatake	X	x	x	x	x
available		{true, false}	Type: boolean; required Dark current measurement before earth data take exists (yes) or not (no)		x	x	x	x
status		{-1, 0, 1}	Type: integer; required Test status: WARNING = -1, ERROR = 0, FAULTLESS = 1		x	x	x	x
darkAfterQuality	available status		Type: structure; required Contains screening results of dark current	X	x	x	x	x

Parameter	Unordered list of sub-elements	Value Range	Remarks	Uploaded Searchable	DC	CAL	Exp	Earth
			measurements after datatake					
available		{true, false}	Type: boolean; required Dark current measurement after earth data take exists (yes) or not (no)		x	x	x	x
status		{-1, 0, 1}	Type: integer; required Test status: WARNING = -1, ERROR = 0, FAULTLESS = 1		x	x	x	x

Table 7-1 DESIS L1A Metadata

7.2 Example of Metadata file

```
<?xml version="1.0" encoding="UTF-8"?>
<hsi_doc xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="DESIS_schema_L1A.xsd">
    <metadata>
        <name>DESIS-HSI-L1A-DT0000010031_001-20180221T044135-
V0100_METADATA.xml</name>
        <comment>DESIS_Hyperspectral_Image_Raw_Data</comment>
        <copyright>DLR</copyright>
        <license>DLR_internal_usage</license>
    </metadata>
    <base>
        <version>01.00</version>
        <sphere>earth</sphere>
        <size>476</size>
        <level>L1A</level>
        <format>bil</format>
        <spatialCoverage>
            <boundingPolygon>
                <point>
                    <frame>point_1</frame>
                    <latitude>-49.4457912073</latitude>
                    <longitude>105.1072599158</longitude>
                </point>
                <point>
                    <frame>point_5</frame>
                    <latitude>-49.4457912073</latitude>
                    <longitude>105.1072599158</longitude>
                </point>
                <point>
                    <frame>point_4</frame>
                    <latitude>-49.1643053123</latitude>
                    <longitude>105.2177212011</longitude>
                </point>
                <point>
                    <frame>point_3</frame>
                    <latitude>-49.2520826837</latitude>
                    <longitude>105.6071394344</longitude>
                </point>
                <point>
                    <frame>point_2</frame>
                    <latitude>-49.5339764621</latitude>
                    <longitude>105.4987992739</longitude>
                </point>
                <point>
                    <frame>center</frame>
                    <latitude>-49.3490389163</latitude>
                    <longitude>105.3577299563</longitude>
                </point>
            </boundingPolygon>
        </spatialCoverage>
```

```
        <altitudeCoverage>419790.8</altitudeCoverage>
        <temporalCoverage>
            <startTime>2018-02-21T04:41:29.000346Z</startTime>
            <endTime>2018-02-21T04:41:33.000692Z</endTime>
        </temporalCoverage>
    </base>
    <specific>
        <mission>DESIS</mission>
        <satelliteID>ISS</satelliteID>
        <sensor>HSI</sensor>
        <sensorMaxBands>235</sensorMaxBands>
        <acquisitionMode>image_strip_mode</acquisitionMode>
        <requestID>1541</requestID>
        <datatakeID>0000010031</datatakeID>
        <imageID>0000010031001</imageID>
        <tileID>001</tileID>
        <numberOfTiles>1</numberOfTiles>
        <numberOfBands>235</numberOfBands>
        <pixelSize unit="m">30</pixelSize>
        <widthOfScene>1024</widthOfScene>
        <heightOfScene>1040</heightOfScene>
        <missionPhase>commissioning</missionPhase>
        <orbitDirection>DESCENDING</orbitDirection>
        <orbitType>precision</orbitType>
        <processingDateTime>2017-06-20T14:48:10.562885Z</processingDateTime>
        <processingCenter>NZ</processingCenter>
        <processingNode>thales.af.op.dlr.de</processingNode>
        <processible>1</processible>
        <sunAzimuthAngle>139.055710</sunAzimuthAngle>
        <sunZenithAngle>90.000000</sunZenithAngle>
        <sceneAzimuthAngle>102.542967</sceneAzimuthAngle>
        <sceneIncidenceAngle>2.80</sceneIncidenceAngle>
        <lowGainFactor>1</lowGainFactor>
        <highGainFactor>5</highGainFactor>
        <configFPA>rolling_shutter</configFPA>
        <pointingMirrorAngle>0.000000</pointingMirrorAngle>
        <qualityIndicator>
            <screeningStatus>0</screeningStatus>
            <screeningResult>
                <parameter>
                    <status>1</status>
                    <name>T_POI_1</name>
                    <type>temperature</type>
                    <description>Temperature at POI 1</description>
                    <value>25.0</value>
                    <units>degC</units>
                </parameter>
                <parameter>
                    <status>-1</status>
                    <name>P_FPA</name>
                    <type>power</type>
                    <description>Power at Focal Plane Area</description>
                    <value>3.5</value>
                    <info>value below limit</info>
                    <units>mW</units>
```

```
                <parameter>
            </screeningResult>
            <darkBeforeQuality>
                <available>true</available>
                <status>1</status>
            </darkBeforeQuality>
            <darkAfterQuality>
                <available>false</available>
                <status>0</status>
            </darkAfterQuality>
        </qualityIndicator>
    </specific>
</hsi_doc>
```

8. Reference Information for L1B, L1C, L2A Product Metadata

8.1 Metadata Cards

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
				L1B	L1C	L2A
hsi_doc	metadata processing base specific		Root of xml doc	X	X	X
metadata	name comment copyright license		General information about the metadata file itself and copyright notice	X	X	X
name		DESIS-<product_type>-DT<datatake_ID>_<tile_ID>-<yyyymmdd>T<hhmmss>-<version>_METADATA.xml	Type: string Name of the product metadata file	X	X	X
comment			Type: string Free text field	X	X	X
copyright		DLR	Type: string Copyright information	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
license		DLR internal usage	Type: string Constant value	X	X	X
processing	coRegistration mapProjection imageResampling backgroundValue versionDEM versionREF terrainCorrection ozoneValue productType test		General information about the processing parameters to generate the product (e.g. product format, type, resampling, map projection)	X	X	X
coRegistration		{Yes, No, none}	Type: string In case of rolling shutter the L1B product can be resampled in order to achieve co-registration of the channels. None is used if no active selection is performed	X	X	X
mapProjection		{UTM_Zone_of_Center, UTM_Zone_of_Center(-1), UTM_Zone_of_Center(+1), Geographic, none}	Type: string none if not selected (e.g. for L1B product)	X	X	X
imageResampling		{Nearest_Neighbour, Bilinear_Interpolation, Cubic_Convolution, none}	Type: string none if not selected (e.g. for L1B product)	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
backgroundValue		Example: -32768	Type: short Used to set the background value of the spectral image	X	X	X
versionDEM		Examples SRTM-C-X_vv.rr, best-of-DEM_vv.rr, ASTER-GDEM_vv.rr, none}	Type: string Used DEM for geometric processing internal processing parameter	X	X	X
versionREF		{Image2006_vv.rr, Image2009_vv.rr ,USGS-ETM+LandCover_vv.rr, GLS2010, none	Type: string Used Reference for GCP extraction internal processing parameter currently always "none". None is used if no active selection is performed	X	X	X
terrainCorrection		{Yes, No, none}	Type: string none if not selected	X	X	X
ozoneValue		[200,…,500] or 0 (zero)	Type: integer 0 (zero) if not selected	X	X	X
productType		{L1B, L1C, L2A}	Type: string Product level coming with this metadata file	X	X	X
test		{true, false}	Type: Boolean Marks the product as test	X	X	X
base	version revision		Contains basic information about the data (e.g. location, time, processing level)			

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
	l1aVesrion sphere size level format spatialCoverage altitudeCoverage temporalCoverage					
version		{nn.nn}	Type: string Global Version of the processing chain	X	X	X
revision		{nn.nn}	Type: string Version of the processor being executed	X	X	X
l1aVersion		{nn.nn}	Type: string Version of the L1A processor, which produced the L1A product stored in the database	X	X	X
sphere		{earth, none}	Type: string Should be always "earth" for DESIS products. None is used for future expansion.	X	X	X
size		[0,…,-]	Type: non-negative integer Size of product in GiB of the unzipped product	X	X	X
level		{L1B,L1C,L2A}	Type: string Product Level	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
format		{TIF}	Type: string Image Format of product	X	X	X
spatialCoverage	boundingPolygon		Contains information on the spatial coverage of the product w.r.t. the WGS84 geodatic datum.	X	X	X
boundingPolygon	point		The bounding polygon is a list of points starting with the most starboard pixel of the first scanline and followed by a counter-clockwise sequence of four points, whereas the last point is identical with the first point. See Figure 8-3	X	X	X
point	frame latitude longitude		Type: string (for frame) The frame can be element from {center, point_1, point_2, point_3, point_4, point_5} Type: double (for latitude and longitude) longitude can be [-180° west of Greenwich,…,+180 east of Greenwich] latitude can be [-90° south of equator,…,+90° north of equator]	X	X	X
altitudeCoverage			Type: double Mean platform height above WGS84 ellipsoid during data acquisition given in kilometer	X	X	X
temporalCoverage	startTime endTime		Contains the time of the first scanline acquistion and the last scanline acquistion given in UTC	X	X	X
startTime endTime		2017-04-15 T01:45:11.123456Z	Type: DateTime startTime: time of first scanline in UTC (e.g. 2017-04-15T01:45:11.123456Z) endTime: time of last scanline in UTC (e.g. 2017-04-15T01:46:05.123456Z) for an acquistion with rolling shutter the time is related to first channel of the	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
			image			
specific	mission satelliteID sensor sensorMaxBands acquisitionMode requestID datatakeID imageID tileID numberOfTiles numberOfBands bandCharacterisation pixelSize widthOfScene heightOfScene missionPhase orbitDirection orbitType processingDateTime processingCenter processingNode processible			X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
	qualityFlag meanGroundElevation meanSlope meanWaterVapour qualityWV stripingBanding generalArtifacts defectivePixels smileIndication orthoRMSE_x orthoRMSE_y orthoRe meanVisibility qualityVIS meanAerosolOpticalThickness percentageHazequalityHaze percentageClouds qualityCloud percentageCloudShadow qualityCloudShadow percentageTopoShadow qualityTopoShadow					

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
	aerosolType season sunAzimuthAngle sunZenithAngle sceneAzimuthAngle sceneIncidenceAngle qualitySZA sceneAzimuthAngle qualityIndicator auxDataVersion lowGainFactor highGainFactor configFPA pointingMirrorAngle boresightAngles interiorOrientation orbit attitude					
mission		DESIS	Type: string Mission name is constant	X	X	X
satelliteID		ISS	Type: string satelliteID is constant	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
sensor		HSI	Type: string Sensor is constant	X	X	X
sensorMaxBands		[0-235]	Type:integer Ideally constant as 235 along all the mission.	X	X	X
acquisitionMode		{image_strip_mode, image_stereo_mode}	Type: string Defines the acquistion mode. The image_strip_mode is the normal earth imaging mode, whereas the image_stereo_mode is an experimental mode with up to 3 images of the same ground target area in one datatake for stereo and BRDF evaluations.	X	X	X
requestID			Type: string Unique request identifier generated by TBE	X	X	X
datatakeID		[0000000001,…,9999999999]	Type: string (10 digits) Unique datatake ID. Example: 1234567890	X	X	X
imageID		[0010000001,…,9909999999]	Type: string (13 digits) The unique imageID is composed of the datatakeID and the tileID by imageID = string(datatakeID)+string(tileID) Example: 1234567890003	X	X	X
tileID		[001,…,999]	Type: string (3 digits) Tile number within a datatake increasing timely starting from 001. Example: 003	X	X	X
numberOfTiles		[1,…999]	Type: integer	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
			Total number of tiles of the datatake			
numberOfBands		[1,…,235]	Type: integer Number of spectral channels of the tile	X	X	X
bandCharacterisation	band					
band	bandNumber wavelengthCenterOfBand wavelengthWidthOfBand gainOfBand offsetOfBand deadPixels suspiciousPixel		Contains information valid for each spectral band of the image	X	X	X
bandNumber		[1,…,235]	Type: integer Sequence of increasing spectral band numbers corresponding to increasing wavelengths as stored sequential in the image data cube	X	X	X
wavelengthCenterOfBand		[350,…,1050]	Type: double Center wavelength in [nm] of spectral band. See Figure 8-1	X	X	X
wavelengthWidthOfBand		[0,…,20]	Type: double FWHM in [nm] of band. See Figure 8-1	X	X	X
gainOfBand offsetOfBand		[0,…,-]	Type: double For L1B and L1C products From the pixel values (DN = digital number) in the specific band the Top-of-Atmosphere Radiance given in [mW/cm2/sr/µm] can be calculated by	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
			L=OffsetOfBand+GainOfBand*DN For L2A products From the pixel values (DN = digital number) in the specific band the reflectance with a value between 0 and 1.0 can be calculated by L=OffsetOfBand+GainOfBand*DN			
deadPixels		[0,…,100]	Type: double Percentage of dead pixels in the band derived from calibration.	X	X	X
suspiciousPixel		[0,…,100]	Type: double Percentage of suspicious pixels in the band derived from data screening	X	X	X
pixelSize		[30,..,50] Angle TBD	Type: float This element has an attribute (unit = m for meter in case of not Geographic Map Projection and unit = d for decimal degree in case of Geographic Map Projection) which defines the resolution of the pixel. For L1B products this is an approximate value.	X	X	X
widthOfScene		1024 (default)	Type: integer Number of spectral pixels in a scanline (across direction)	X	X	X
heightOfScene		1024 (default)	Type: integer Number of pixels in alongtrack direction	X	X	X
missionPhase		{pre-launch, leop, commissioning, routine}	Type: string Phase where the datatake is acquired	X	X	X
orbitDirection		{ASCENDING, DESCENDING}	Type: string Ascending or descending mean orbit direction within an image tile	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
orbitType		{predicted, precision}	Type: string Defines the orbit type	X	X	X
processingDateTime		2013-04-15 T01:45:11.123456Z	Type: dateTime Processing date and time in UTC	X	X	X
processingCenter		{NZ, OP,TBE}	Type: string Name of processing center OP = DLR@Oberpfaffenhofen and NZ = DLR@Neustrelitz TBE = Teledyne	X	X	X
processingNode			Type: string Provided by command ‘hostname’	X	X	X
processible		{-1,0,1}	Type: integer Specifies if a data set was processible =0 or not =1 or suspicious 1	X	X	X
terrain	meanGroundElevation meanSlope				X	X
meanGroundElevation			Type: double Mean ground elevation given in meter above WGS84		X	X
meanSlope			Type: double Mean slope value given in decimal degree		X	X
waterVapour	meanWaterVapour					X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
	qualityWV					
meanWaterVapour		[0.01,…,6.00]	Type: double Mean water vapour column (WV) in centimeter.			X
qualityWV		{reduced, normal}	Type: string If WV > 4cm: reduced quality, WV > 5cm: low quality			X
visibility	meanVisibility qualityVIS					X
stripingBanding		{0-100, 255}	Type: byte Value in percent of affected pixels in dataset; {255}: not produced see [AD05]	x	x	x
generalArtifacts		{0-100, 255}	Type: byte Value in percent of affected pixels in dataset; {255}: not produced see [AD05]	x	x	x
defectivePixels		{0-100, 255}	Type: byte Value in percent of affected pixels in dataset; {255}: not produced see [AD05]	x	x	x
smileIndication		{0-100, 255}	Type: byte Probability of detected smile. {0-100}: low vales indicate a low probability for spectral smile, high values indicate a high probability of spectral smile}; {255}: not produced see [AD05]	x	x	x
orthoRMSE_x		[0,…,-] or -1	Type: double Linear RMSE in x direction (west-east) in meter -1 if no matching is performed. The value is a worst case estimation, because - the outlier detection within the sensor model is not performed		X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
			- the tie points with lower quality measure are used (the best ones are used for the GCPs)			
orthoRMSE_y		[0,…,-] or -1	Type: double Linear RMSE in y-direction (north-south) in meter -1 if no matching performed The value is a worst case estimation, because - the outlier detection within the sensor model is not performed - the tie points with lower quality measure are used (the best ones are used for the GCPs)		X	X
numPointsGCP		[0,…,-]	Type: integer Number of GCP to improve sensor model		X	X
numPointsICP		[0,…,-]	Type: integer Number of ICP used to derive orthoRMSE		X	X
matchingMethod		{LLSQ, BRISK, SIFT,none}	Type: string Image matching method that produced the GCP/ICP point set *LLSQ: Local Least Squares* *BRISK: Binary Robust Invariant Scalable Keypoints* *SIFT: Scale-invariant feature transform*		X	X
percentageCloudShadow		[0,…100]	Type: double Percentage of cloud shadow in the image			X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
qualityCloudShadow		{reduced, normal}	Type: string If percent of cloud shadow >10%: reduced quality			X
topoShadow	percentageTopoShadow qualityTopoShadow					X
percentageTopoShadow		[0,…100]	Type: double Persentage of topographic shadow in the image			X
qualityTopoShadow		{reduced, normal}	Type: string If percent of topographic shadows > 10%: reduced quality			X
meanAerosolOpticalThickness		[0,…,1.0]	Type: double Mean aerosol optical thickness at 550 nm			X
aerosolType		{rural, urban, maritime, desert}	Type: string Aerosol type used for atmospheric correction			X
season		{summer, winter}	Type: srtring Season used type for atmospheric correction			X
sunAzimuthAngle			Type: double The value is derived at the scene center and counted positive from north clockwise. The value is given in decimal degree.	X	X	X
sunZenithAngle		[0,…90]	Type: double The value is derived w.r.t. WGS84 at the center of scene. The value is given in decimal degree.	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
sceneAzimuthAngle		[0,…,360]	Type: double This value has two different meanings depending on the product level For L1B: see Figure 8-4 Scene azimuth definition for L1A and L1B products The value is derived from the mean path w.r.t. north direction and counted positive clockwise. The value is given in decimal degree. For L1C and L2A: see Figure 8-5 Scene azimuth definition for L1C and L2A pro View-azimuth of the scene in decimal degree (north=0, east=90, south=180, west=270) measured at ground in center of scene. Both define spherical coordinates where the satellite can be seen during acquisition))	X	X	X
sceneIncidenceAngle		[0,…,90]	Type: double The angle between normal at the scene center and the lock direction of the sensor. The value is given in decimal degree. (see 8.3.4)	X	X	X
qualitySZA		{reduced, low, normal}	Type: string If SZA >55: reduced quality, SZA > 65: low quality			X
qualityIndicator	screeningStatus screeningResult darkBeforeQuality darkAfterQuality		Type: structure; required Includes the screening results of housekeeping parameters in the virtual channel and the quality of the dark current measurements	X	X	X
screeningStatus		{-1,0,1}	Type: integer; required Screening result status can be a WARNING (-1), an ERROR (0), or FAULTLESS (1)	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
screeningResult	parameter		Type: structure; required, one or more sets Container for one tested housekeeping parameter in the virtual channel	X	X	X
parameter	status name type description info value units		Type: structure Information about a tested physical or (device or command) status parameter, includes description of properties and test results	X	X	X
status		{-1, 0, 1}	Type: integer; required Test status: WARNING = -1, ERROR = 0, FAULTLESS = 1	X	X	X
name			Type: string; required Unique name code of the parameter	X	X	X
type		{temperature, voltage, current, power, status}	Type: string; required Predefined parameter type description, list can be extended	X	X	X
description			Type: string; optional Human readable parameter description as free text	X	X	X
info			Type: string; optional Information in case of failure or limit violation	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
value			Type: string; required one value or a list of values, separated by comma or space	X	X	X
units			Type: string; optional Physical unit of <value> or '1'	X	X	X
darkBeforeQuality	available status		Type: structure; required Contains screening results of dark current measurements before datatake	X	X	X
available		{yes, no}	Type: string; required Dark current measurement before earth data take exists (yes) or not (no)	X	X	X
status		{-1, 0, 1}	Type: integer; required Test status: WARNING = -1, ERROR = 0, FAULTLESS = 1	X	X	X
darkAfterQuality	available status		Type: structure; required Contains screening results of dark current measurements after datatake	X	X	X
available		{yes, no}	Type: string; required Dark current measurement after earth data take exists (yes) or not (no)	X	X	X
status		{-1, 0, 1}	Type: integer; required Test status: WARNING = -1, ERROR = 0, FAULTLESS = 1	X	X	X
lowGainFactor		{1,2}	Type:integer Gain setting of the sensor for low gain	X	X	X
highGainFactor		{5,10}	Type:integer Gain setting of the sensor for high gain	X	X	X

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
configFPA		{rolling_shutter, global_shutter}	Type: string Shutter mode of the focal plane array	X	X	X
pointingMirrorAngle		[-7.5,…,7.5]	Type: double Angle of the pointing mirror measured in decimal degree. Forward looking is positive and backward looking is negative. The angle is given in decimal degree. In case of fail save the angle -0.0 is written and different geometric calibration tables will be used according to the mounting of the second fixed mirror. The value “-0.0” should be checked on a string basis.	X	X	X
deltaOmegaFM		[-180,…,180]	Fixed mirror mounting angle X (see [AD05] for the definition of the calibrated angle). The angle is given in decimal degree.	X		
deltaPhiFM		[-180,…,180]	fixed mirror mounting angle Z (see [AD05] for the definition of the calibrated angle). The angle is given in decimal degree.	X		
betaFM		[-180,…180]	fixed mirror mounting angle Y (see [AD05] for the definition of the calibrated angle). The angle is given in decimal degree.	X		
deltaOmegaPOI		[-180,…180]	POI mounting angle X (see [AD05] for the definition of the calibrated angle). The angle is given in decimal degree.	X		
deltaPhiPOI		[-180,…180]	POI mounting angle Z (see [AD05] for the definition of the calibrated angle). The angle is given in decimal degree.	X		
betaPOI		[-180,…180]	POI mounting angle Y (see [AD05] for the definition of the calibrated angle). The angle is given in decimal degree.	X		
boresightAngles	rotX rotY rotZ		Contains information on sensor mounting angles.The boresight angles define the rotation of the sensor coordinate frame to the coordinate frame of the attitude measurment system (Startracker, Gyro)	X		

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
rotX rotY rotZ			Type: double Sensor mounting angles. The angles are given in decimal degree.	X		
interiorOrientation	band		Contains information on the calibrated object sided look angles	X		
band	bandNumber calAngles			X		
bandNumber		[0,1,…235]	Type: integer Number of the band for which the calibration value is valid If bandNumber=0 only one calAngles structure is defined and the measurment values are valid for each band, which means no keystone is present.	X		
calAngles	pixelNumber phiX phiY		Contains information on the object sided look angles at specific pixel positions. The angles are given in decimal degree. See 8.3.2	X		
pixelNumber phiX phiY			Type: integer for pixelNumber Type: double for phiX and phiY For each pixel in the band the two object sided look angles are given. The angles are given in decimal degree. See Figure 8-2 Definition of object sided angles of the interior orientation	X		
orbit	leapSeconds origin stateVector		Contains information for geometric processing	X		

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
leapSeconds		[0,…,-]	Type: integer Leap seconds between GPS time and UTC time	X		
origin			Type: string Origin of data stream (e,g. BAD)	X		
stateVector	timeUTC timeGPS point		Contains information on satellite position and velocity	X		
timeUTC			Type: dateTime UTC time of position / velocity	X		
timeGPS			Type: double GPS time of position / velocity with microsecond resolution	X		
point	location velocity		Contains location and velocity of the satellite	X		
location	X Y Z		Contains position of the satellite Origin: Mass center of Earth defined by WGS84 X points to Greenwich Z points to Earth rotation axes Y complements right handed Cartesian frame	X		
X		[-,-]	Type: double	X		

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
Y Z			Position of satellite w.r.t. WGS84 frame. The position is given in meter.			
velocity	X Y Z		Contains velocity of satellite	X		
X Y Z		[-,-]	Type: double Velocity of satellite w.r.t. WGS84 frame. The velocity is given in meter per second.	X		
attitude	referenceFrame leapSeconds origin stateVector		Contains information on the attitude	X		
referenceFrame		{ECR,ECI,ORBIT}	Type: string Defines the coordinate frame against the attitude is measured	X		
leapSeconds		[0,…,-]	Type: integer Leap seconds between GPS time and UTC	X		
origin			Type: string Origin of data stream	X		
stateVector	timeUTC timeGPS angle		Contains the list of MUSES attitude values	X		

Parameter	Unordered list of sub-elements	Value Range	Remarks	Availability		
timeUTC			Type: dateTime UTC time of attitude measurement	X		
timeGPS			Type: double GPS time of attitude measurement with microsecond resolution	X		
angle	q1 q2 q3 q4		Contains attitude of the satellite	X		
q1 q2 q3 q4		[-,-]	Type: double Quaternions (w,x,y,z)	X		

Table 8-1 Metadata for L1B, L1C, and L2A products

8.2 Example of Metadata file

The following example contains all metadata cards and is not a real example for a specific product (see Availability column in section 8.1). This example shows the metadata for a L2A product

```
<?xml version="1.0" encoding="UTF-8"?>
<hsi_doc                                                    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="DESIS_schema_L2A.xsd">
 <metadata>
  <name>DESIS-HSI-L1C-DT0000050000_001-20060919T105200-V0085_METADATA.xml</name>
  <comment>DESIS_Hyperspectral_Image_geometric_corrected_data</comment>
  <copyright>DLR</copyright>
  <license>DLR_internal_usage</license>
 </metadata>
 <processing>
  <coRegistration>none</coRegistration>
  <mapProjection>Geographic</mapProjection>
  <imageResampling>Bilinear_Interpolation</imageResampling>
  <backgroundValue>0</backgroundValue>
  <versionDEM>SRTM_CFILT</versionDEM>
  <versionREF>GMB</versionREF>
  <terrainCorrection>Yes</terrainCorrection>
  <ozoneValue>330</ozoneValue>
  <productType>L2A</productType>
  <test>true</test>
 </processing>
 <base>
  <version>00.85</version>
  <l1aVersion>00.85</l1aVersion>
  <sphere>earth</sphere>
  <size>1089</size>
  <level>L2A</level>
  <format>TIF</format>
  <spatialCoverage>
   <boundingPolygon>
    <point>
     <frame>point_1</frame>
     <latitude>53.939463</latitude>
     <longitude>9.526409</longitude>
    </point>
    <point>
     <frame>point_2</frame>
     <latitude>53.939463</latitude>
     <longitude>12.408935</longitude>
    </point>
    <point>
     <frame>point_3</frame>
     <latitude>53.171052</latitude>
     <longitude>12.408935</longitude>
    </point>
    <point>
     <frame>point_4</frame>
     <latitude>53.171052</latitude>
     <longitude>9.526409</longitude>
    </point>
    <point>
```

```
      <frame>point_5</frame>
      <latitude>53.939463</latitude>
      <longitude>9.526409</longitude>
     </point>
     <point>
      <frame>center</frame>
      <latitude>53.0</latitude>
      <longitude>11.0</longitude>
     </point>
    </boundingPolygon>
   </spatialCoverage>
   <altitudeCoverage>400000.0</altitudeCoverage>
   <temporalCoverage>
    <startTime>2014-07-11T08:06:52.000000Z</startTime>
    <endTime>2014-07-11T08:06:53.000000Z</endTime>
   </temporalCoverage>
  </base>
  <specific>
   <mission>DESIS</mission>
   <satelliteID>ISS</satelliteID>
   <sensor>HSI</sensor>
   <sensorMaxBands>235</sensorMaxBands>
   <acquisitionMode>image_strip_mode</acquisitionMode>
   <requestID>0000</requestID>
   <datatakeID>0000050000</datatakeID>
   <imageID>0000050000001</imageID>
   <tileID>001</tileID>
   <numberOfTiles>1</numberOfTiles>
   <numberOfBands>235</numberOfBands>
   <bandCharacterisation>
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     <wavelengthCenterOfBand>399.94</wavelengthCenterOfBand>
     <wavelengthWidthOfBand>3.5</wavelengthWidthOfBand>
     <gainOfBand>100</gainOfBand>
     <offsetOfBand>0.0</offsetOfBand>
     <deadPixels>0.0</deadPixels>
     <suspiciousPixel>0.0</suspiciousPixel>
    </band>
    <band>
     <bandNumber>2</bandNumber>
     <wavelengthCenterOfBand>403.667</wavelengthCenterOfBand>
     <wavelengthWidthOfBand>3.5</wavelengthWidthOfBand>
     <gainOfBand>100</gainOfBand>
     <offsetOfBand>0.0</offsetOfBand>
     <deadPixels>0.0</deadPixels>
     <suspiciousPixel>0.0</suspiciousPixel>
    </band>
    <band>
     <bandNumber>3</bandNumber>
     <wavelengthCenterOfBand>406.2</wavelengthCenterOfBand>
     <wavelengthWidthOfBand>3.5</wavelengthWidthOfBand>
     <gainOfBand>100</gainOfBand>
     <offsetOfBand>0.0</offsetOfBand>
     <deadPixels>0.0</deadPixels>
     <suspiciousPixel>0.0</suspiciousPixel>
    </band>
    <band>
```

```
      <bandNumber>4</bandNumber>
      <wavelengthCenterOfBand>408.681</wavelengthCenterOfBand>
      <wavelengthWidthOfBand>3.72183</wavelengthWidthOfBand>
      <gainOfBand>100</gainOfBand>
      <offsetOfBand>0.0</offsetOfBand>
      <deadPixels>0.0</deadPixels>
      <suspiciousPixel>0.0</suspiciousPixel>
    </band>
…
    <band>
      <bandNumber>234</bandNumber>
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      <wavelengthWidthOfBand>6.0</wavelengthWidthOfBand>
      <gainOfBand>100</gainOfBand>
      <offsetOfBand>0.0</offsetOfBand>
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      <suspiciousPixel>0.0</suspiciousPixel>
    </band>
    <band>
      <bandNumber>235</bandNumber>
      <wavelengthCenterOfBand>998.05</wavelengthCenterOfBand>
      <wavelengthWidthOfBand>5.5</wavelengthWidthOfBand>
      <gainOfBand>100</gainOfBand>
      <offsetOfBand>0.0</offsetOfBand>
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      <suspiciousPixel>0.0</suspiciousPixel>
    </band>
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  <widthOfScene>2741</widthOfScene>
  <heightOfScene>949</heightOfScene>
  <missionPhase>commissioning</missionPhase>
  <orbitDirection>DESCENDING</orbitDirection>
  <orbitType>precision</orbitType>
  <processingDateTime>2018-07-03T10:58:22.791758Z</processingDateTime>
  <processingCenter>OP</processingCenter>
  <processingNode>thales.af.op.dlr.de</processingNode>
  <processible>1</processible>
  <terrain>
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    <meanSlope>0.1</meanSlope>
  </terrain>
  <waterVapour>
    <meanWaterVapour>1.0</meanWaterVapour>
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  </waterVapour>
  <stripingBanding>0</stripingBanding>
  <generalArtifacts>0</generalArtifacts>
  <defectivePixels>0</defectivePixels>
  <smileIndicator>0</smileIndicator>
  <orthoRMSE_x>-1</orthoRMSE_x>
  <orthoRMSE_y>-1</orthoRMSE_y>
  <numPointsGCP>0</numPointsGCP>
  <numPointsICP>0</numPointsICP>
  <matchingMethod>none</matchingMethod>
  <visibility>
    <meanVisibility>88.89</meanVisibility>
    <qualityVIS>normal</qualityVIS>
```

```
  </visibility>
  <haze>
   <percentageHaze>38.3672361583</percentageHaze>
   <qualityHaze>reduced</qualityHaze>
  </haze>
  <clouds>
   <percentageClouds>5.20654049713</percentageClouds>
   <qualityClouds>normal</qualityClouds>
  </clouds>
  <cloudShadow>
   <percentageCloudShadow>0.51718258702</percentageCloudShadow>
   <qualityCloudShadow>normal</qualityCloudShadow>
  </cloudShadow>
  <topoShadow>
   <percentageTopoShadow>0.0</percentageTopoShadow>
   <qualityTopoShadow>normal</qualityTopoShadow>
  </topoShadow>
  <meanAerosolOpticalThickness>0.100934937045</meanAerosolOpticalThickness>
  <aerosolType>rural</aerosolType>
  <season>summer</season>
  <sunAzimuthAngle>110.47</sunAzimuthAngle>
  <sunZenithAngle>48.64</sunZenithAngle>
  <sceneAzimuthAngle>177.70658</sceneAzimuthAngle>
  <sceneIncidenceAngle>27.5</sceneIncidenceAngle>
  <lowGainFactor>2</lowGainFactor>
  <highGainFactor>5</highGainFactor>
  <configFPA>rolling_shutter</configFPA>
  <pointingMirrorAngle>0.000000</pointingMirrorAngle>
  <qualitySZA>normal</qualitySZA>
  <qualityIndicator>
   <screeningStatus>1</screeningStatus>
   <screeningResult>
    <parameter>
     <status>1</status>
     <name>FPGA</name>
     <type>temperature</type>
     <description>something</description>
     <info>info</info>
     <value>20</value>
     <units>deg</units>
    </parameter>
   </screeningResult>
   <darkBeforeQuality>
    <available>true</available>
    <status>1</status>
   </darkBeforeQuality>
   <darkAfterQuality>
    <available>true</available>
    <status>1</status>
   </darkAfterQuality>
  </qualityIndicator>
 </specific>
</hsi_doc>
```

8.3 Explanations

8.3.1 wavelengthCenterOfBand & wavelengthWidthOfBand

The center of a spectral band (wavelengthCenterOfBand) and the width of a spectral band (wavelengthWidthOfBand) is illustrated in Figure 8-1

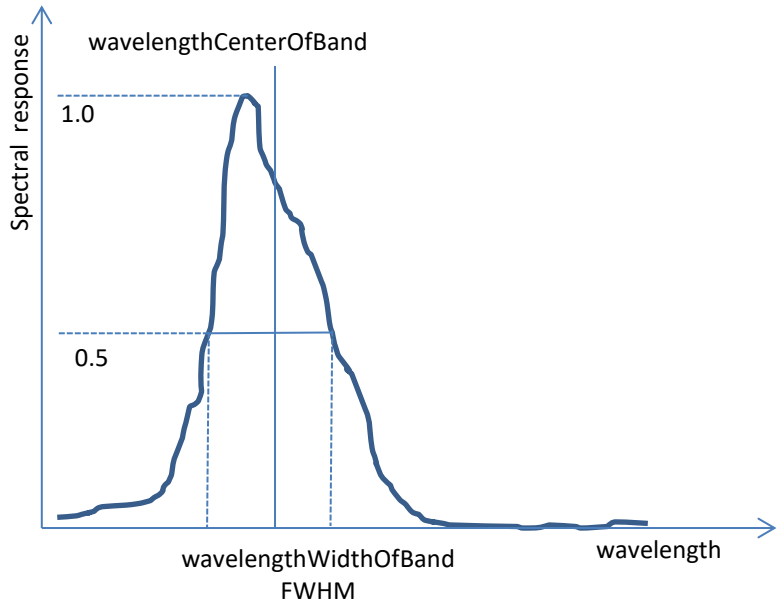

Figure 8-1 Ilustration of center wavelength and FWHM

8.3.2 calAngles

The geometric calibration angles are illustrated in Figure 8-2

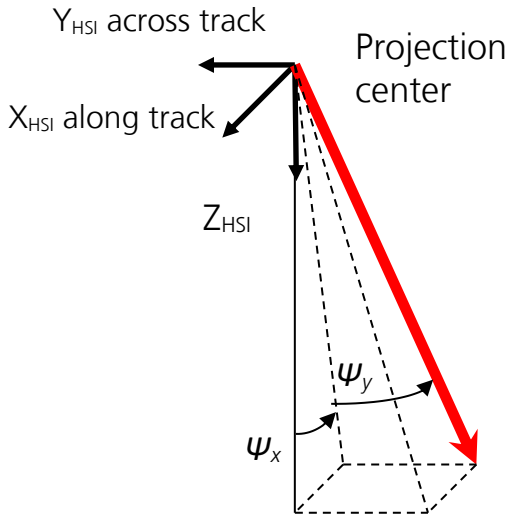

Figure 8-2 Definition of object sided angles of the interior orientation

8.3.3 boundingPolygon

The bounding polygon is illustrated in Figure 8-3

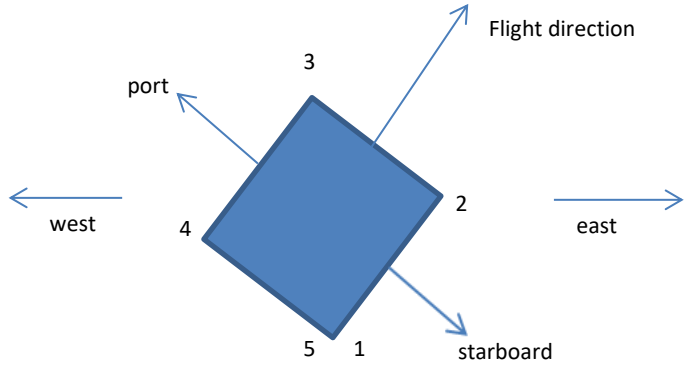

Figure 8-3 Example of an image bounding polygon with ascending ISS orbit direction

8.3.4 sceneIncidentAngle and sceneAzimuthAngle

The sceneIncidentAngle and the sceneAzimuthAngle is calculated using a sphere model of the Earth. The definitions of these two angles are illustrated in Figure 8-4 for the L1A and L1B product and in Figure 8-5 for the L1C and L2A product

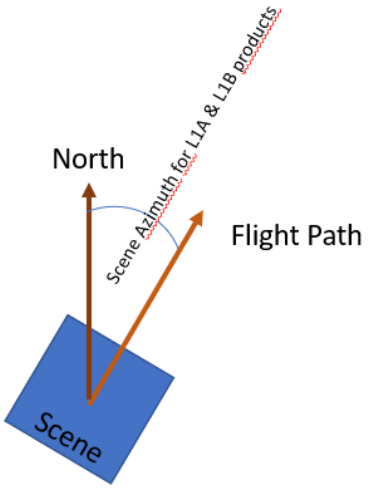

Figure 8-4 Scene azimuth definition for L1A and L1B products

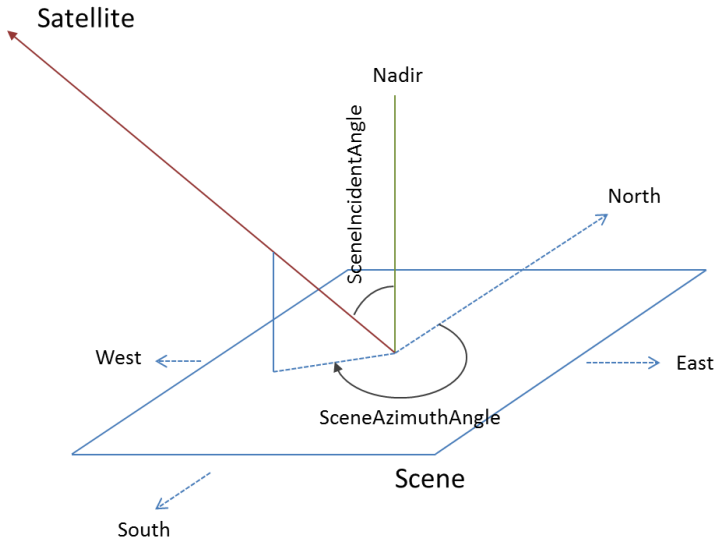

Figure 8-5 Scene azimuth definition for L1C and L2A products

Please note that the naming “sceneAzimuth” in the metadata file is identical for L1A&L1B and for L1C&L2A products, but with different meaning

9. Reference Information for L1A, L1B, L1C, L2A Product History

9.1 History Cards Description

Parameter	Unordered list of sub-elements	Data Type	Value Range	Description	Mandatory
base	- mission - instrument - source - destination - productType - productParameter - productFile - productOperations - status - remark	Root parameter		Define a history block within the history file, enclosing all history parameters within a deeper level for every data product. The parameter <base> must exist at least once and it can occur multiple times	Yes
base/mission	(none)	String of maximum 256 characters	DESIS	Identify mission that produced the data. It is a fixed string	Yes
base/instrument	(none)	String of maximum 256 characters	01	Identify the DESIS instrument that produced the data	Yes
base/source	- name - revision - time	Root parameter		Identify a block in the XML file describing the source of the data product or data component which was needed to produce a data product	Yes
base/source/name	(none)	String of maximum 256 characters	- TBE - Ground Data System XX - Data and Information Management System XX - Processing System XX	Name of the source program/system that generated the product	Yes
base/source/version	(none)	String of maximum 256 characters	VV.VV	Version of the source program/system that generated the product	Yes
base/source/time	(none)	DateTime	YYYY-MM-DD HH:MM:SS	Timestamp for source data creation	Yes
base/destination	- name	Root parameter		Identify a block in the XML file describing the destination of the data	No

Parameter	Unordered list of sub-elements	Data Type	Value Range	Description	Mandatory
	- version - time			product	
base/destination/name		String of maximum 256 characters	- Ground Data System XX - Data and Information Management System XX - Processing System XX - User XX	Name of the destination program/system that receives the product	No
base/destination/version	(none)	String of maximum 256 characters	VV.VV	Version of the source program/system that receives the product	No
base/destination/time	(none)	DateTime	YYYY-MM-DD HH:MM:SS	Timestamp for destination data creation	No
base/productType	(none)	String of maximum 65536 characters		Describes the type of product exchanged	Yes
base/productParameter	(none)			Specifies the parameters used to generate the product	Yes
base/productFile	- name - hash	Root parameter		Specifies details about the product file exchanged	Yes
base/productFile/name		String of maximum 256 characters		Specifies the product file name	Yes
base/productFile/hash	- algorithm - value	Root parameter		Optional hash value computed for the product file using one of the available hash algorithms	No
base/productFile/hash/algorithm	(none)	String of maximum 256 characters	CRC32, SHA256	Algorithm used to compute the hash value of the data product file	No
base/productFile/hash/value	(none)	String of maximum 256 characters		Hash value computed for the product file using the algorithm given by base/productFile/hash/name	No
base/productOperations	(none)	String of maximum 65536 characters		Operations performed by the source for the exchanged product	No
base/status	(none)	String of maximum 256 characters	ERROR, WARNING, FAULTLESS	Specifies the output status flag after execution of the process	Yes
base/remark	(none)	String of maximum		Includes possible remarks relevant for the data product that shall be	No

Parameter	Unordered list of sub-elements	Data Type	Value Range	Description	Mandatory
		65536 characters		part of the product history	

9.2 Example of History file

```
<base>
    <mission>DESIS</mission>
    <instrument>01</instrument>
    <source>
        <name>DESIS L1A Processor</name>
        <revision>01.02</ revision >
        <time>2017-11-25 13:57:11</time>
    </source>
    <destination>
        <name>DESIS L1B Processor</name>
        <revision>01.03</revision>
    </destination>
    <productType>Level 1B Earth</productType>
    <productParameter>tile 001 of datatake 10003219 at 2017-11-13 07:21:03</productParameter>
    <productFile>
        <name>DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100-METADATA.xml</name>
        <hash>
```

<algorithm>CRC32</algorithm>
<value> accf8b33</value>
</hash>
</productFile>
<productFile>
<name> DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100-SPECTRAL_IMAGE.tif </name>
<hash>
<algorithm> SHA256 </algorithm>
<value>2a94a200762a30cc332703c4ef4b1c6af40e76e1a9214e3bfc6d2049878f6c9e</value>
</hash>
</productFile>
<productFile>
<name> DESIS-HSI-LXX-DT0010357991_003-20171013T035442-V0100-HISTORY.xml </name>
</productFile>
<status>FAULTLESS</status>
<base>
<mission>DESIS</mission>
<instrument>01</instrument>
<source>
<name>TBE</name>
<revision>01.00</revision>
<time>2017-11-14 21:58:35</time>
</source>
<destination>
<name>L1A Processor</name>
<revision>01.02</revision>
<time>2017-11-14 01:58:11</time>

```
            </destination>
            <productType>Level 1A Earth</productType>
            <productParameter> tile 001 of datatake 0010357991 at 2017-11-13 07:21:03</productParameter>
              . . .
            <status>FAULTLESS</status>
        </base>
    </base>
```

10. Open Issues

All open and undecided questions in this document, are marked as To Be Defined (TBD) and are summarized in the following table Most of the TBD will be clarified after the final instrument design is available.

TBD ID Topic	Comment	Expected Resolving
[TBD01] Usage of compression on raw data	Not discarded the possibility to have the raw data compressed when downloaded from TBE	TBE during DESIS-PAV phase D Resolved – no compression
[TBD02] Auxiliary data format	Format of the DESIS auxiliary data acompanying the DESIS raw data not established yet. Waiting for TBE to provide this information	resolved 30.07.2018
[TBD03] Size of data products	Size of many files of the DESIS data products are not defined yet. Waiting for input from space segment, TBE, etc.	TBE, SS, during DESIS-PAV phase D Resolved – File size added
[TBD04] Calibration Configuration	Not defined yet the configuration used for each type of calibration (number of frames, number of wavelengths, number of intensities, type of linearity measurement, etc.). Waiting for the space segment to provide this description	SS after laboratory tests or during commissioning phase resolved
[TBD05] DC Measurement Configuration	Not defined yet the numer of DC frames taken before and after each datatake or calibration measurement	SS after laboratory tests or during commissioning phase resolved
[TBD06] Additional files in data product	Possibility to add more files with copyright notice or help information for the user still open	GS during DESIS-PAV phase D Resolved – currently no additional files
[TBD07] Temporary Area Name L1A Data Product	Not established yet the name for the temporary area of L1A data product files	GS during DESIS-PAV phase D resolved
[TBD08] Permanent Area Name L1A Data Product	Not established yet the name for the permanent area of L1A data product files	GS during DESIS-PAV phase D resolved
[TBD09] Temporary Area Name DC Data Product	Not established yet the name for the temporary area of DC data product files	GS during DESIS-PAV phase D resolved
[TBD10] Permanent Area Name DC Data Product	Not established yet the name for the permanent area of DC data product files	GS during DESIS-PAV phase D resolved
[TBD11] Temporary Area Name DC Data Product	Not established yet the name for the temporary area of Cal data product files	GS during DESIS-PAV phase D resolved
[TBD12] Permanent Area Name Cal Data Product	Not established yet the name for the permanent area of Cal data product files	GS during DESIS-PAV phase D resolved
[TBD13] Details of auxiliary data files	Details on the number of auxiliary data files and their names not established yet. Waiting for TBE to provide this information	GS during DESIS-PAV phase D resolved

TBD ID Topic	Comment	Expected Resolving
[TBD14] Linearity measurements	Currently no on-board linearity calibration is planned. The space segment has not defined a corresponding calibration sequence.	SS decision during commissioning phase Resolved – currently no linearity tables are provide by DLR-OS

Table 10-1 List of TBD