Swarm

Level 1b Product Definition

National Space Institute
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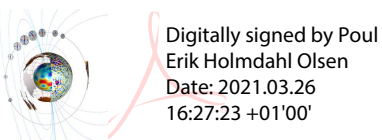

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DOCUMENT CHANGE LOG

Issue	Change References	Issue Date	Pages Affected	Remarks	Init.
1		2006-09-19	All	Initial Issue	LTC
2		2007-01-31	All	Updated data products Added data products Added Product Definition section Updated Excel document on the details of the Product Format	HF
2		2007-02-02		Included the detailed product description in Section 6 Small update of doc.	HF
3		2007-04-27	7-35	Updated according to Level 1b Requirements Review; in particular Sections 5.2 and 6	LTC
4		2007-09-07	All	Generel update Added ASMX_AUX1B and VFMX_AUX1B Products Many minor changes	LTC
4.1		2008-03-10	7,9, 15-18, 24, 32-46	Added/updated flags Updated ACC product. Various minor updates Added Maneuver information	LTC
4.2		2008-09-29	Many	Added MAGXEUL_1B Product, updated EFIX_PL_1B (no 16 Hz elements) and ACCX_PR_1B Products. Updated MODX_SC_1B Product to contain SP3-c and STR Instrument Level Data Sets. Removed MOD-acceleration	LTC

Issue	Change References	Issue Date	Pages Affected	Remarks	Init.
				Extended MAGX_HR_1B and related products length to 1 day Moved "_" in AUX product names	
5		2008-12-19	10,14-15, 17-19, 30-32,34, 38,41-50	Changed format of time information to CDS standard Fixed alignment (2-/4-byte) of Products by re-arrangement of elements and addition of fillers Plasma Product updated, TCF.LP MDR added MDR_MAG_CA and TCF.VFM MDR updated MAGXEUL_1B updated Removed geolocalisation information from SPH Split Ephemeris Product in three – removed STR level attitude information	LTC
5.1		2009-02-27	10,24f,31f, 34-38, 41-43, 46-51	Added MDR_ID fields. Removed Phase, Cycle and Rel_Orbit from MPH. Corrected size of B_error in MDR_MAG_HR	LTC
5.2		2009-05-15	9,11,18f, 21,23,25, 31-35, 48-54, 57f	MPH field values update Added missing product specific parts of SPH MAGXEUL_1B, EFIX_PL_1B, and ACCX_PR_1B (**aa**$_{Sun}$ removed) updated	LTC
5.3		2009-10-09	12, 13, 16, 17, 21, 22, 27-30, 32-36, 38, 49, 51-52,	Added the products MAGXMAN_1B, LP_X_CA_1B, and TIIX_CA_1B Removed SPH fields 1.5.2	LTC

Issue	Change References	Issue Date	Pages Affected	Remarks	Init.
			55-56, 58-60	through 1.5.5 (ISPs missing) from MAGXEUL_1B Increased precision of Plasma Product elements Increased sampling rate of MAGX_CA_1B from 0.25 Hz to 1 Hz Message text replaced by id numbers in MAGXMAN_1B Changed Primary_EU to DPU_id in TCF.VFM Added VFM_q and ASM_q_VFM to ASMXAUX_1B and VFMXAUX _1B SPH's Small updates of MPH and SPH (acquisition station ID and harmonization)	
5.4		2010-01-29	9, 12-13, 16, 23-24, 27-30, 42, 46, 49-51, 56-57, 59, 62-64, 75	Added missing CHANGE text for Issue 5.3 above Added SyncStatus Added ASM_Freq_Dev element to MAGX_LR_1B Updated ACCX_PR_1B and TIIX_CA_1B Extended fixed header field description (reformed Table 4-1), small updates of various MPH and SPH fields Corrected offsets and size of MDR_EFI_PL	LTC
5.5		2010-05-17	27-28, 39, 54	MAGXEUL_1B clarifications and detailing of its Product File content	LTC

Issue	Change References	Issue Date	Pages Affected	Remarks	Init.
5.6		2010-05-28	25, 31-32, 51, 57-58, 64-65	Updated MPH.Product_Err description. Corrected dimension and field size of ASM_VFM_IC.W_scale Updated ACC housekeeping information fields Removed TBD and TBC, changed a few scaling factors (SF)	LTC
5.7		2011-02-01	24, 43, 47, 50, 57, 62	Corrected scaling factor (SF) of radiuses. Corrected from unsigned to signed integer of dF_Xxx Added missing fields to TIIX_CA_1B product and reduced r1_samples to single number	LTC
5.8		2011-06-20	13, 21-22, 41, 57-58	Changed field name of plasma density from "ne" to "n" – including error estimate and flags. Corrected number of records in TIIX_CA_1B to one. Corrected dimensions of dv_mtq_H/V to one and updated product size accordingly.	LTC
5.9		2011-10-14	18, 51, 65	Changed types of Cov and W_scale in ASM_VFM_IC to signed integers. Changed description of W_scale (now $\log_{10}$ values). Updated names in Table 4-5 to be aligned with Section 6.4. Changed scaling factor (SF) of ACC.K_Earth (4 → 3) Corrected offset of ACC.Thru_Acc_On element.	LTC

Issue	Change References	Issue Date	Pages Affected	Remarks	Init.
5.10		2011-11-07	33	Modified value of State_Vector_Source in MPH	LTC
5.11		2012-03-01	27, 44, 45, 47, 49, 50, 52, 59-60, 66	Changed scale factor (SF) of latitude and longitude in MAGx_yy_1B and EFIx_PL_1B from 6 to 7. Changed scale factor (SF) of var_x/y_V/H in EFIx_PL_1B from 3 to 5. Added flag value 255 (no sample) to Flags_F and Flags_q. Specified ranges of latitude and longitude information (±90° respectively ±180°). Specified timestamp of ACCx_PR_1B product is of linear acceleration measurement.	LTC
5.12		2013-09-27	15, 26, 31, 44, 48-49, 60, 70, 71-72	Added Appendix B on Reference Frames. Note on time span of RINEX products (Section 5.2.1) and reference frames of SP3c files (Section 4.4.2). Specified representation of NaN's in Plasma product (Sections 6 and 6.8). Added missing values of Flags_q (Table 6-1). Added NaN and WGS84 acronyms.	LTC

Issue	Change References	Issue Date	Pages Affected	Remarks	Init.
5.13		2013-10-09	33, 35, 39	Updated in accordance with SPR-171: Increased length of MPH. Delta_UT1 field (Table 5-1) Added file extension to SPH.DSD.File_Name in the case of CCDB file (Table 5-2) Length of SPH.Ephemeris_ Information.RINEX_ Filename shortened and set for MODx_SC_1B product (Table 5-7)	LTC
5.14		2014-03-26	18-19, 28, 31, 44-47, 51, 53, 58, 68	Specified values of F and B in case Flags = 255 (Sections 4.2, 6.1, and 6.2). Clarified meaning of $Flags_q$ values 16-18 (Table 6-1). Changed units of T_{Gas} from K to °C, Thru_Acc_On ignored (set to zero), binary format of effective area normals changed from unsigned to signed (Sections 4.4.3 and 6.16) Clarified end time of MAGXMAN product and changed units of delta_t from days to seconds (Sections 5.2.1 and 6.7)	LTC
5.15	AI-261 AI-223	2014-08-29	16-17, 42 21, 54 69 71	Adjusted VFM sampling frequency to *approximately* 50 Hz (Tables 4-1 and 5-12) Corrected description of F in MAGx_CA_1B Increased precision of ACC proof-mass position field to nm (Section 6.16) Removed “magneto-torquer” flag values from ACC (Table 6-6)	LTC

Issue	Change References	Issue Date	Pages Affected	Remarks	Init.
5.16	UPID-22[1]	2014-12-09	21	Corrected description of F_{VFM} and dt_{VFM} in MAGx_CA_1B	LTC
5.17		2015-07-10	18-19, 21, 23, 47, 51, 54, 56	Added dB_Sun element to MAGx_HR_1B, MAGx_LR_1B and VFMxAUX_1B Added dB_Sun, B_pre, alpha and beta elements to MAGx_CA_1B an corrected desctription	JBN
			24, 62	Corrected description of Latitude, Longitude, dt_PL, n_error, T_elec_error and U_SC_error in MDR_EFI_PL Removed values and corrected description of Flags_LP and Flags_LP_xxx (Table 6-4)	
5.18		2016-04-20	19	Format column added and [kbytes/min] column removed from Table 4-1	JBN
			31, 43	.ZIP structure and CDF product files added to product description	
			45-59	Data Set Definition tables changed to match CDF product files	
			51	Change field name of DPU_ID to Primary_EU	
5.19		2016-11-04	20-23	Description of $\mathbf{B}_{error}$ and F_{error} updated	JBN

[1] UPID refers to planned update ID's in Section 3 of SW-PL-DTU-GS-008, "Planned Updates for Level 1b"

Issue	Change References	Issue Date	Pages Affected	Remarks	Init.
5.20		2017-01-05	19 19, 31, 43 18-53 23	Extension column added to Table 4-1 ASCII file products change from .DBL to native extensions MAGXEUL_1B removed from document Description of F_{error} updated	JBN
5.21		2018-07-05	19, 30-30, 42, 44, 58-59 19, 26-27, 42, 44, 53-56 18-57 44	ACCX_PR_1B split into a changed ACCX_PR_1B and a new SC_XDYN_1B EFIX_PL_1B redefined as EFIX_LP_1B and EFIXLPI introduced TIIX_CA_1B removed from document MDR_ID column removed from Table 5-12	JBN
5.22		2018-08-24	42 52 53	Corrected MDR_EFI_LPI to MDR_EFILPI and MDR_EFI_PL to MDR_EFI_LP (Table 5-12) Removed "N_e" from Timestamp description (Section 6.8) Corrected MDR_EFI_LPI to MDR_EFILPI in heading and corrected Timestamp description (Section 6.9)	LTC
5.23		2019-04-26	57	*Maneuver_Id* removed from table in Section 6.17	JBN
5.24		2020-04-17	2 47	Removed Issue Record "*normal or burst*" added to Flags_F = 0 description	LTC JBN
5.25		2020-06-17	28, 56-57	$\mathbf{a}_{centr}$ and $\mathbf{a}_{GG}$ are moved from ACCx_PR_1B to SC_xDYN_1B	JBN

Issue	Change References	Issue Date	Pages Affected	Remarks	Init.
				$Flags_{ACC}$ and $Flags_{Platform}$ are removed from ACCx_PR_1B	
5.26		2021-01-27	19, 21, 47, 49	dF_{Sun} added to MAGx_LR_1B and MAGx_CA_1B	JBN
			23, 50	dB_{Sun} added to ASMx_AUX_1B	
			20, 24, 47, 49, 50	dB_{Sun} Description revised in MAGx_LR_1B, MAGx_CA_1B and VFMx_AUX_1B	
			28, 57	$Flags_q$ added to SC_xDYN_1B	
			52 –54	Updated description of $Flags_{LP}$ in MDR_EFI_LP and MDR_EFILPI	

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Appendices

1. Introduction

1.1 Scope

The present document is prepared as part of the Swarm Level 1b Processor specification. It defines the contents of the Swarm Level 1b Products.

2. Applicable and Reference Documents

2.1 Applicable Documents

AD01 Swarm PDS-IPF ICD Generic Interface Guidelines
Doc. No: SW-ID-ESA-GS-0001
ESA ESTEC, Noordwijk, The Netherlands

AD02 Swarm Level 0 Product Format
Doc. No: SWARM-GSEG-EOPG-05-001
ESA ESTEC, Noordwijk, The Netherlands

AD03 Earth Explorer File Format Standards
Doc. No: PE-TN-ESA-GS-0001
ESA ESTEC, Noordwijk, The Netherlands

AD04 Tailoring of File Format Standards to Swarm Mission
Doc. No: SW-TN-ESA-GS-0074
ESA ESTEC, Noordwijk, The Netherlands

AD05 Swarm Level 0 Products
Doc. No: SW.IF.EAD.GS.00017
EADS Astrium, Friedrichshafen, Germany

2.2 Reference Documents

RD01 RINEX: The Receiver Independent Exchange Format Version 3.00
http://igscb.jpl.nasa.gov/igscb/data/format/rinex300.pdf
by Werner Gurtner, Astronomical Institute, University of Bern
Dated: 2006-12-19

RD02 Swarm Level 1b Processor Algorithms
Doc. No: SW-RS-DSC-SY-0002
National Space Institute, Technical University of Denmark

RD03 Swarm Level 1b Processor Characterisation and Calibration Data Base
Doc. No: SW-TN-DSC-SY-0005
National Space Institute, Technical University of Denmark

RD04 Swarm GPSR TE-12 Instrument L1b Algorithms Definition
Doc. No. SW-TN-SES-GP-0018
Saab Space AB, Sweden

RD05 The Extended Standard Product 3 Orbit Format (SP3-c)
http://igscb.jpl.nasa.gov/igscb/data/format/sp3c.txt
by Steve Hilla, National Geodetic Survey, NOAA, USA
Dated: 12 February 2007

RD06 Swarm CEFI-LP Level 1b Algorithms
Doc. No: SW-TN-IRF-EF-003
Swedish Institute of Space Physics, Uppsala

RD07 Technical note on error estimates for L1b magnetic products
Doc. No: SW-TN-DTU-GS-016
National Space Institute, Technical University of Denmark

3. Contents

This document contains the description of the Swarm Level 1b Products, i.e. the description of the output of the Level 1b Processor.

Chapter 4 contains an overview of the Level 1b Products.

Chapter 5 contains the general structure of the Level 1b Product files.

Chapter 6 contains the detailed format description of the Level 1b Products.

4. Overview of Level 1b Products

This section contains short listings of all Level 1b Data Products provided by the Level 1b Processor. First, a list of the products is provided in Section 4.1 followed by descriptions of the three logical groups: magnetic, plasma, and position in separate subsections.

The detailed, complete descriptions and formats of the Products are given in Section 6.

A summary of the various reference frames is given in Appendix B.

4.1 Swarm Level 1b Products

The following table identifies the Level 1b Products for Swarm. The Products with a daily period are provided covering one day of observations, i.e. 0:00:00 through 24:00:00 (UTC or GPS in case of RINEX files). The estimated sizes do not include header file information (see Section 5).

File Type	File Description	Rate	Period	Format	Extension	Estimated Size [Mbytes/file]
MAGX_HR_1B	Magnetic vector data, high rate	~50 Hz	daily	CDF	.cdf	341
MAGX_LR_1B	Magnetic data, low rate	1 Hz	daily	CDF	.cdf	10.8
MAGX_CA_lB	Magnetic Calibration data	1 Hz	daily	CDF	.cdf	10.6
MAGXMAN_1B	Magnetic Calibration Manoeuvre report	< 1 month	monthly	CDF	.cdf	10^{-3}
EFIX_LP_1B	Plasma data	2 Hz	daily	CDF	.cdf	TBD
EFIXLPI_1B	Interpolated Plasma data	1 Hz	daily	CDF	.cdf	TBD
LP_X_CA_1B	Langmuir Probe offset calibration data	6 h	daily	CDF	.cdf	10^{-3}
MODX_SC_1B	Position and velocity	1 Hz	daily	ASCII	.sp3	20.0
STRXATT_1B	Attitude of spacecraft	1 Hz	daily	CDF	.cdf	2.7

File Type	File Description	Rate	Period	Format	Extension	Estimated Size [Mbytes/file]
GPSXNAV_1B	On-board GPSR navigational solution	1 Hz	daily	ASCII	.sp3	12.7
GPSX_RO_1B	GPS RINEX Observation data	0.1 Hz	daily	ASCII	.rnx	86.9
GPSX_RN_1B	GPS RINEX Navigation data	2 h	daily	ASCII	.rnx	0.25
ACCX_PR_1B	Pre-processed ACC data	1 Hz	daily	CDF	.cdf	TBD
SC_XDYN_1B	Auxiliary data for precise orbit determination and acceleration modelling	1 Hz	daily	CDF	.cdf	TBD
ASMXAUX_1B	ASM auxiliary data	~50 Hz	daily	CDF	.cdf	19.6
VFMXAUX_1B	VFM auxiliary data	~50 Hz	daily	CDF	.cdf	14.4

X = A, B or C defining the satellite

Table 4-1 Swarm Level 1b Products List

4.2 Magnetic Products

The primary Level 1b Products containing measurements of the magnetic field are MAGX_HR_1B and MAGX_LR_1B. They are largely identical with respect to the elements of the products, but the sampling rate of the data is different. MAGX_HR_1B is provided at the basic sampling rate of the vector magnetometer instrument (VFM), 50 Hz. This product is called *Mag-H* for short and is described in Section 4.2.1. The MAGX_LR_1B product contains magnetic vector data at a reduced sampling rate of 1 Hz plus the measurements of the magnetic field intensity from the scalar magnetometer (ASM) and is termed *Mag-L* for short. This is described in Section 4.2.2.

The magnetic vector elements of the MAGX_HR_1B and MAGX_LR_1B Products are provided in two reference frames: the VFM instrument frame and the orbit related NEC (North-East-Centre) frame. See [RD02] for further details on these frames.

The magnetic Level 1b product named MAGX_CA_lB (*Mag-C* for short) contains the data used for the monitoring and estimation of the temporal VFM calibration parameters. Its content is described in Section 4.2.3. The temporal VFM parameters themselves are contained in an auxiliary data set, TCF.VFM, and stored in the magnetic products listed here. This Data Set is described in Section 4.2.4.

The MAGXMAN_1B Product contains the report of the TCF.VFM records, their differences, and threshold checks when a magnetic calibration manouevre has been performed. See Section 4.2.5.

There are two additional magnetic products, ASMXAUX_1B and VFMXAUX_1B, containing the magnetic stray fields of the S/C at the ASM respectively the VFM sensor positions. They are used during special campaigns, e.g. when the ASM instrument is running in the special *burst mode* or *vector mode* configuration. Their contents are listed in Sections 4.2.6 and 4.2.7.

4.2.1 MAGX_HR_1B Product

The MAGX_HR_1B Product contains magnetic vector data at 50 Hz rate. The time instants of the data are determined by the VFM instrument samplings. No interpolation of the magnetic data is performed, neither to shift the measurements in time nor to fill any gaps in the VFM source data. The measurement data set record of the MAGX_HR_1B Product is described in Table 4-2. See also Section 6.1.

t	Time, UTC
r	Position of VFM sensor in ITRF, spherical geocentric coordinates
$\mathbf{B}_{\mathrm{VFM}}$	Magnetic field vector, VFM frame
$\mathbf{B}_{\mathrm{NEC}}$	Magnetic field vector, NEC frame. Note: this is set to zero if no attitude information is available (Flags_q = 255)
$\mathbf{dB}_{\mathrm{Sun}}$	Sun induced stray magnetic field correction vector subtracted from measurements, VFM frame
$\mathbf{dB}_{\mathrm{AOCS}}$	AOCS magneto-torquer stray magnetic field correction vector subtracted from measurements, VFM frame.
$\mathbf{dB}_{\mathrm{other}}$	Stray magnetic field correction vector of all other sources subtracted from measurements, VFM frame.
$\mathbf{B}_{\mathrm{error}}$	Error estimate on magnetic field vector, VFM frame. Accounts for errors of commissioning including: • Instrument noise • Uncertainties in instrument calibration and characterization • Uncertainties in corrections of stray fields from spacecraft For further details please consult [RD07]

$\mathbf{q}_{NEC \leftarrow CRF}$	Rotation from NEC to Common Reference Frame (CRF)
Att_{error}	Error estimate on attitude information. Includes effects such as number of STR camera heads supplying attitude information, possible discrepancies in provided attitude information from several heads, lack of STR attitude information (i.e. the attitude used for computing $\mathbf{B}_{NEC}$ is obtained by interpolation over longer arcs of S/C motion), etc.
$Flags_B$	Flags related to the magnetic field vector measurement
$Flags_q$	Flags related to the attitude data
$Flags_{Platform}$	Flags related to the S/C platform – Bus and AOCS telemetry, position accuracy

Table 4-2 Measurement Data Set Record of MAGX_HR_1B Product

4.2.2 MAGX_LR_1B Product

The MAGX_LR_1B Product contains magnetic vector and scalar data at 1 Hz rate. The S/C data are processed to provide MAGX_LR_1B data at exact UTC seconds, i.e. both VFM vector and ASM scalar data are interpolated to yield these data. Hence, small gaps in the VFM or ASM data need not cause gaps in the product as the gaps may be filled by this interpolation. Any gaps, however, will have an impact on the error estimate of the associated product element. The measurement data set record of the MAGX_LR_1B Product is described in Table 4-3. See also Section 6.2.

t	Time, UTC
r	Position of VFM sensor in ITRF, spherical geocentric coordinates
F	Magnetic field intensity ("scalar magnetic field") Note: this is set to zero if insufficient scalar magnetometer measurements are available ($Flags_F$ = 255)
dF_{Sun}	Sun induced stray magnetic field intensity subtracted from scalar measurements; Sun induced stray field at ASM sensor
dF_{AOCS}	AOCS magneto-torquer stray magnetic field intensity subtracted from scalar measurements
dF_{other}	Stray magnetic field intensity of all other sources subtracted from scalar measurements

F_{error}	Error estimate on magnetic field intensity. Accounts for errors of commissioning including: • Instrument noise • Uncertainties in instrument calibration and characterization • Uncertainties in corrections of stray fields from spacecraft • High frequency (ca 0.1 - 2 Hz) signal content For further details please consult [RD07]
$\mathbf{B}_{VFM}$	Magnetic field vector, VFM frame. Note: this is set to zero if insufficient vector magnetometer measurements are available ($Flags_B$ = 255)
$\mathbf{B}_{NEC}$	Magnetic field vector, NEC frame. Note: this is set to zero if insufficient vector magnetometer or attitude measurements are available ($Flags_B$ = 255 or $Flags_q$ = 255)
$\mathbf{dB}_{Sun}$	Sun induced stray magnetic field correction vector subtracted from measurements, VFM frame; Sun induced stray field at VFM sensor
$\mathbf{dB}_{AOCS}$	AOCS magneto-torquer stray magnetic field correction vector subtracted from vector measurements, VFM frame.
$\mathbf{dB}_{other}$	Stray magnetic field correction vector of all other sources subtracted from vector measurements, VFM frame.
$\mathbf{B}_{error}$	Error estimate on magnetic field vector, VFM frame. Accounts for errors of commissioning including: • Instrument noise • Uncertainties in instrument calibration and characterization • Uncertainties in corrections of stray fields from spacecraft • High frequency (ca 2 - 12 Hz) signal content which is reduced in extraction of 1 Hz data from 50 Hz measurements For further details please consult [RD07]
$\mathbf{Q}_{NEC \leftarrow CRF}$	Rotation from NEC to Common Reference Frame (CRF)
Att_{error}	Error estimate on attitude information. Includes effects such as number of STR camera heads supplying attitude information, possible discrepancies in provided attitude information from several heads, lack of STR attitude information (i.e. the attitude used for computing $\mathbf{B}_{NEC}$ is obtained by interpolation over longer arcs of S/C motion), etc.
$Flags_F$	Flags related to the magnetic field intensity measurement
$Flags_B$	Flags related to the magnetic field vector measurement

$Flags_q$	Flags related to the attitude data
$Flags_{Platform}$	Flags related to the S/C platform – Bus and AOCS telemetry, position accuracy
ASM_ Freq_Dev	Deviation of actual ASM frequency calibration data from screened and filtered value

Table 4-3 Measurement Data Set Record of MAGX_LR_1B Product

4.2.3 MAGX_CA_1B Product

The MAGX_CA_1B Product contains magnetic vector and scalar data for monitoring, TCF.VFM verification, and calibration purposes. It contains raw as well as processed VFM vector measurements, VFM temperatures, and fully converted and corrected ASM measurements at 1 Hz rate. This is essentially the data used for the TCF.VFM estimation but including also the raw VFM data. The measurement data set record of the MAGX_CA_1B Product is described in Table 4-4. See also Section 6.3.

t	Time, UTC
r	Position in ITRF, spherical geocentric coordinates
F	Converted and corrected magnetic field intensity from ASM – *not* adjusted for filter group delay
dF_{Sun}	Sun induced stray magnetic field intensity at ASM sensor
dF_{AOCS}	Stray magnetic field intensity correction of AOCS magneto-torquers
dF_{other}	Stray magnetic field intensity correction of all other sources.
F_{error}	Error estimate on magnetic field intensity. Accounts for errors of commissioning including: • Instrument noise • Uncertainties in instrument calibration and characterization • Uncertainties in corrections of stray fields from spacecraft For further details please consult [RD07] observing that $F_{error} = F^{(3)}_{err}$
F_{VFM}	Converted, corrected, ASM-filtered and interpolated magnetic field intensity from VFM
dt_{VFM}	Time offset, $dt_{VFM} = t_{out,VFM}^{near} - t^{shifted}$, where $t_{out,VFM}^{near}$ is the time-stamp of the VFM sample nearest t shifted according to the ASM filter group delay ($t^{shifted} \approx$ t - 1.2 s)
B	Converted and corrected magnetic field vector from VFM at time $t^{shifted}+dt_{VFM}$
$\mathbf{dB}_{Sun}$	Magnetic stray field vector of Sun induced stray field at VFM sensor at time $t^{shifted}+ dt_{VFM}$
$\mathbf{dB}_{AOCS}$	Magnetic stray field vector of AOCS magneto-torquer at VFM sensor at time $t^{shifted}+dt_{VFM}$

$\mathbf{dB}_{other}$	Magnetic stray field vector of all other sources at VFM sensor at time $t^{shifted}+dt_{VFM}$
$\mathbf{B}_{pre}$	Pre-calibrated VFM magnetic field vector, VFM frame at time $t^{shifted}+ dt_{VFM}$
$\mathbf{EU}_{VFM}$	Raw VFM measurement at time $t^{shifted}+dt_{VFM}$
T_{CDC}	Temperature of VFM CDC at time $t^{shifted}+dt_{VFM}$
T_{CSC}	Temperature of VFM CSC at time $t^{shifted}+dt_{VFM}$
T_{EU}	Temperature of VFM electronic unit at time $t^{shifted}+dt_{VFM}$
alpha	Solar inclination angle, rotation about –y axis, S/C frame at time $t^{shifted}+dt_{VFM}$
beta	Solar inclination angle, angleto –y axis, S/C frame at time $t^{shifted}+dt_{VFM}$

Table 4-4 Measurement Data Set Record of MAGX_CA_1B Product

4.2.4 TCF.VFM Data Set

The TCF.VFM Data Set contains the parameters of the model of the temporal changes in the VFM instrument. The TCF.VFM Data Set Record shall be included in all three magnetic products: MAGX_HR_1B, MAGX_LR_1B, and MAGX_CA_1B. This data set contains one record per day and is described in Table 4-5 below. See also Section 6.4.

t_{range}	Time interval of the VFM measurements used in estimating the parameters
DPU_id	Specifies the active VFM DPU (Data Processing Unit) identifier
Bias	Vector of offsets
Scale	Vector of scale values
Non-orth	Vector of non-orthogonality angles
Samples	Number of samples used to estimate the parameters
Rms	Weighted rms (root-mean-square) value of obtained misfit between VFM and ASM measurements
Cov	Covariances of the estimated parameters
$\mathbf{W}_{scale}$	Log10 values of actual weigths of a-priori parameters (affected by e.g. maneouvers)

Table 4-5 TCF.VFM Data Set Record

4.2.5 MAGXMAN_1B Product

The MAGXMAN_1B Product contains a report on the VFM temporal parameters in response to a Magnetic Calibration manouevre stored in a VFM_MAN_RP Data Set (Table 4-6 below) as well as two TCF.VFM Data Set records (Table 4-5), the one from just before the manouevre and the one of the day of the manouevre.

Delta_bias	Vector of changes in offsets
delta_scale	Vector of changes in scale values

delta_non-orth	Vector of changes in non-orthogonality angles
Threshold1_bias	Threshold 1 value for biases
Threshold1_scale	Threshold 1 value for scale values
Threshold1_non-orth	Threshold 1 value for non-orthogonality angles
Threshold2_bias	Threshold 2 value for biases
Threshold2_scale	Threshold 2 value for scale values
Threshold2_non-orth	Threshold 2 value for non-orthogonality angles
Messages	Messages generated by the magnetic calibration manouevre processor

Table 4-6 MAGXMAN_1B VFM_MAN_RP Data Set Record

4.2.6 ASMXAUX_1B Product

The ASMXAUX_1B Product contains detailed information on the S/C magnetic stray fields at the ASM sensor position. The data are provided at 50 Hz at the time-instants of the VFM measurements (for internal practical purposes); the stray field vectors are provided in the ASM sensor frame. The measurement data set record of the ASMXAUX_1B Product is described in Table 4-8. See also Section 6.5.

t	Time, UTC
$\mathbf{dB}_{\text{Sun}}$	Magnetic stray field vector of Sun induced stray field at ASM sensor
$\mathbf{dB}_{\text{AOCS}}$	Magnetic stray field vector of AOCS magneto-torquer coils (including magnetically induced effects of this)
$\mathbf{dB}_{\text{Thrust}}$	Magnetic stray field vector of AOCS thruster activation
$\mathbf{dB}_{\text{Battery}}$	Magnetic stray field vector of batteries charge/discharge currents
$\mathbf{dB}_{\text{SP}}$	Magnetic stray field vector of solar panel currents
$\mathbf{dB}_{\text{Bus}}$	Magnetic stray field vector of S/C bus currents
$\mathbf{dB}_{\text{VFM}}$	Magnetic stray field vector of VFM sensor
$\mathbf{dB}_{\text{Static}}$	Static magnetic stray field vector of S/C
$\mathbf{dB}_{\text{Ind}}$	Magnetically induced stray field vector, from S/C
$\mathbf{dB}_{\text{State}}$	Instrument and sub-system state dependent stray field vector, including latch valves

Table 4-8 Measurement Data Set Record of ASMXAUX_1B Product

4.2.7 VFMXAUX_1B Product

The VFMXAUX_1B Product contains detailed information on the S/C magnetic stray fields and the Sun induced stray field at the VFM sensor position. The data are provided at 50 Hz at the time-instants of the VFM measurements; the stray field vectors are provided in the VFM

sensor frame. The measurement data set record of the VFMXAUX_1B Product is described in Table 4-9. See also Section 6.6.

t	Time, UTC
$\mathbf{dB}_{Sun}$	Magnetic stray field vector of Sun induced stray field at VFM sensor
$\mathbf{dB}_{AOCS}$	Magnetic stray field vector of AOCS magneto-torquer coils (including magnetically induced effects of this)
$\mathbf{dB}_{Thrust}$	Magnetic stray field vector of AOCS thruster activation
$\mathbf{dB}_{Battery}$	Magnetic stray field vector of batteries charge/discharge currents
$\mathbf{dB}_{SP}$	Magnetic stray field vector of solar panel currents
$\mathbf{dB}_{Bus}$	Magnetic stray field vector of S/C bus currents
$\mathbf{dB}_{STR}$	Static magnetic stray field vector of STR Camera Head Units (CHUs)
$\mathbf{dB}_{Static}$	Static magnetic stray field vector of rest of S/C
$\mathbf{dB}_{Ind}$	Magnetically induced stray field vector, from S/C
$\mathbf{dB}_{State}$	Instrument and sub-system state dependent stray field vector, including latch valves

Table 4-9 Measurement Data Set Record of VFMXAUX_1B Product

4.3 Plasma Products

4.3.1 EFIX_LP_1B and EFIXLPI_1B Products

The EFIX_LP_1B Product contains plasma data from the Langimur Probe (LP) of the Electrical Field Instrument (EFI). The plasma product encompasses the plasma density and temperature. Data is provided at 2 Hz rate. The time instant are determined by the EFI instruments. No interpolation of the EFI data is performed, neither to shift the measurements in time nor to fill any gaps.

The EFIXLPI_1B Product contains the EFIX_LP_1B plasma data interpolated at full UTC seconds, the same as the low resolution magnetic data MAG_LR.

The measurement data set record of the plasma products is listed in Table 4-10 below. See also Section 6.8 and Section 6.9

t	Time, UTC
r	Position in ITRF, spherical geocentric coordinates
U_{orbit}	Magnitude of S/C velocity in the ITRF
N_e	Plasma density

$N_{e,error}$	Error estimate of N_e
T_e	Plasma electron temperature
$T_{e,error}$	Error estimate of T_e
V_s	S/C potential
$V_{s,error}$	Error estimate of V_s
$Flags_{LP}$	Common flags of the LP data
$Flags_{Ne}$	Flags of the plasma density, N_e
$Flags_{Te}$	Flags of the electron temperature, T_e
$Flags_{Vs}$	Flags of the S/C potential, V_s

Table 4-10 Measurement Data Set Records of EFIX_LP_1B and EFIXLPI_1B Products

4.3.2 LP_X_CA_1B Product

The LP_X_CA_1B Product contains the TCF.LP Data Set records containing the LP calibration parameters determined in the Level 1b Processor from the *Offset Determination Sweep Mode* telemetry including the measurements themselves.

T	Time of the LP Offset Determination Sweep
Probe1_I_Bias_Offset	Probe 1 current bias offset determined
Probe1_I_Slope_Offset	Probe 1 current slope offset determined
Probe1_I_Fit_Error	Error in fit of Probe 1 current sweep data
Probe1_U_Bias_Offset	Probe 1 voltage bias offset determined
Probe1_U_Slope_Offset	Probe 1 voltage slope offset
Probe1_U_Fit_Error	Error in fit of Probe 1 voltage sweep data
Probe2_I_Bias_Offset	Probe 2 current bias offset
Probe2_I_Slope_Offset	Probe 2 current slope offset
Probe2_I_Fit_Error	Error in fit of Probe 2 current sweep data
Probe2_U_Bias_Offset	Probe 2 voltage bias offset determined
Probe2_U_Slope_Offset	Probe 2 voltage slope offset
Probe2_U_Fit_Error	Error in fit of Probe 2 voltage sweep data
FP_I_Bias_Offset	Face Plate current bias offset
FP_I_Slope_Offset	Face Plate current slope offset

FP_I_Fit_Error	Error in fit of Face Plate current sweep data
FP_U_Bias_Offset	Face Plate voltage bias offset
FP_U_Slope_Offset	Face Plate voltage slope offset
FP_U_Fit_Error	Error in fit of Face Plate voltage sweep data
FP_I_offset	Vector of Face Plate current offset measurements
FP_U_offset	Vector of Face Plate bias offset measurements
P1_I_offset	Vector of Probe 1 current offset measurements
P1_U_offset	Vector of Probe 1 bias offset measurements
P1_ref_ADC2	Vector of Probe 1 reference ADC2
P1_ground	Vector of Probe 1 ground
P2_I_offset	Vector of Probe 2 current offset measurements
P2_U_offset	Vector of Probe 2 bias offset measurements
P2_ref_ADC2	Vector of Probe 2 reference ADC2
P2_ground	Vector of Probe 2 ground
P1_Slope	Probe 1 slope offset, determined on-board
P1_Bias	Probe 1 bias offset, determined on-board
P1_Error	Probe 1 fit error, determined on-board
P2_Slope	Probe 2 slope offset, determined on-board
P2_Bias	Probe 2 bias offset, determined on-board
P2_Error	Probe 2 fit error, determined on-board

Table 4-11 TCF.LP Data Set Record

4.4 Position Products

The Swarm "position" Products consists of

- RINEX files containing the GPSR data: GPSX_RO_1B and GPSX_RN_1B (Section 4.4.1)
- Ephemeris products containing on-board navigational solution as well as medium precision orbit information and S/C orientation: GPSXNAV_1B, MODX_SC_1B, and STRXATT_1B (Section 4.4.2)
- Pre-processed non-gravitional acceleration: ACCX_PR_1B (Section 4.4.2).

4.4.1 RINEX Products

The GPSX_RO_1B and GPSX_RN_1B Products store GPSR data in the RINEX 3.00 format generally used for LEO satellites. The description of the format can be found in [RD01] – rinex300.pdf. The contents of the two Products are:

- GPSX_RO_1B: RINEX Observation data files
- GPSX_RN_1B: RINEX Navigation message files

4.4.2 Ephemeris Products

The ephemeris information for Swarm is stored in three products:

- GPSXNAV_1B: Position and velocity from the on-board navigational solution of the GPSR in WGS84. Data Set Records are MDR_NAVSP3 which are SP3c format.
- MODX_SC_1B: Position and velocity from the preliminary Medium Accuracy Orbit Determination (MOD) in ITRF. Data Set Records are MDR_MODSP3 which are SP3c format.
- STRXATT_1B Attitude information at S/C level based on STR data. Data Set Records are MDR_SAT_AT, see Table 4-13.

See Sections 6.12 and 6.13 for detailed descriptions of the Products.

T	Time, UTC
q	Rotation from ITRF to S/C frame (from STR)
$Flags_q$	Flags related to the S/C attitude information (**q**)
Maneuver_Id	Identification of actual S/C maneuver

Table 4-13 S/C Attitude Measurement Data Set Record of STRXATT_1B Product

4.4.3 Acceleration Product

The ACCX_PR_1B Product contains pre-processed acceleration data. The data are not calibrated to the final level of accuracy as this is part of the Precise Orbit Determination (Level 2 processing).

The measurement data set record of the ACCX_PR_1B Product is given in Table 4-14. See also Section 6.16.

t	Time, UTC, ACC linear acceleration measurement time instants, time of angular acceleration measurement is approximately t - 0.12 s
a	Pre-processed linear acceleration data, S/C frame
$\mathbf{a}_{ang}$	Pre-processed angular acceleration data, S/C frame
p	Position of proof mass within ACC cavity, ACC frame
$\mathbf{p}_{ang}$	Angular position of proof mass within ACC cavity, ACC frame

Temp	Temperatures of the ACC
VpLTC1043	Voltage of positive power source of LTC1043 (housekeeping info)
VnLTC1043	Voltage of negative power source of LTC1043 (housekeeping info)
U_{pol}	Polarization voltage

Table 4-14 Measurement Data Set Record of ACCX_PR_1B Product

4.4.4 Spacecraft Dynamics Product

The SC_XDYN_1B Product contains auxiliary data needed for precise orbit determination and non-gravitational force modelling.

The data set record of the SC_XDYN_1B Product is given in Table 4-15.

t	Time, UTC
$\mathbf{a}_{Sun}$	Acceleration due to Solar radiation pressure, S/C frame
$\mathbf{e}_{Sun}$	Direction to the Sun, unit vector, S/C frame
$\mathbf{A}_{Xxx}$	Cross sections of the S/C, orbit frame, Xxx = head, down, left, right
$\mathbf{K}_{Earth}$	Downward optical reflectivity normal
$m_{S/C}$	Mass of S/C
$\mathbf{r}_{CoG}$	Position of CoG, S/C frame
$\mathbf{P}_{Gas}$	Pressure of gas tanks
$\mathbf{T}_{Gas}$	Temperature of gas tanks
$Flags_{Platform}$	Flags related to the S/C platform (indicates if all inputs were available or one or more was missing)
$Flags_q$	Flags related to the attitude data
dt_{thr}	Thruster on-time in seconds (Start of on-time at "Timestamp"), field with 12 colmns (column 1 = ACT 1,… , column 9 = OCT 1,…)
thr_{set}	Flag indicating which thruster branch was active (= 0 for no thrusters powered, = 1 for main units powered, = 2 for redundant units powered, =3 for both main and redundant units powered)
f_{thr}	Nominal thrust force of activated thrusters (combined force), field with 3 columns
$\mathbf{a}_{centr}$	Centrifugal acceleration of ACC proof mass, S/C frame
$\mathbf{a}_{GG}$	Gravity gradient acceleration of ACC proof mass, S/C frame

Table 4-15 Data Set Record of SC_XDYN_1B Product

5. Product Definition

This Section describes the general structure of the Level 1b Product files. Section 6 contains the specific structure and format of the Product File itself.

5.1 General Structure of Product

The structure of the products produced for delivery to the PDGS must follow the requirements of [AD03] as represented in Figure 1 below.

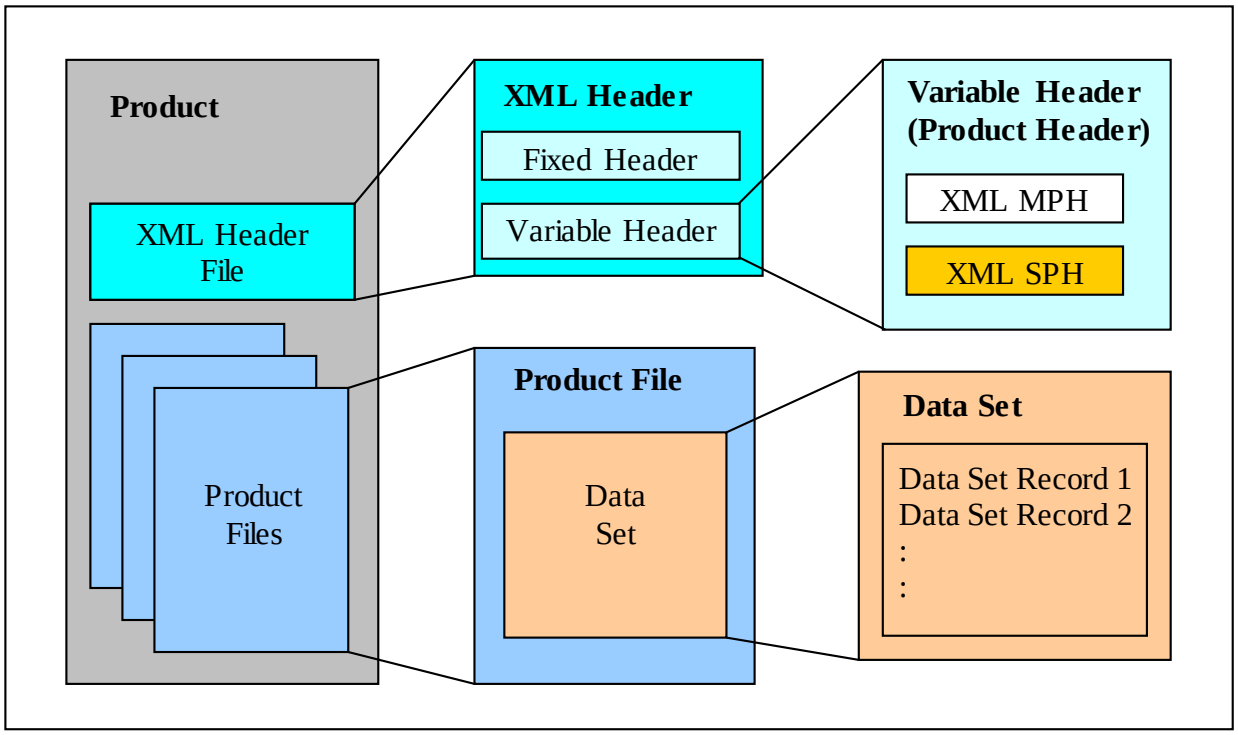


Figure 1 General Product Structure

Each product comes in a zip file composed of one XML Header file and one or more Product Files:

- XML Header files have extension .HDR
- Product Files have extensions .cdf, .sp3 or .rnx (see Table 4-1)

The XML Header (logical) file is an ASCII file containing data information that users can easily access for identifying the product without needs to look inside the Product File.

It consists of (see Section 5.2 for details)

- Fixed Header, a common header for all files in the Swarm Ground Segment

- Variable Header, including
  - ◊ Main Product Header (MPH) containing general information, which is common to all Swarm products
  - ◊ Specific Product Header (SPH) containing product specific and product-wide information. The Specific Product Header will also contain the Data Set Descriptors (DSDs) which provide information on the attached Data Set and references to external files (input files) relevant for the current product

The Product Files are the real products containing the processing results. The Product Files comprise one Data Set (DS) containing the processing results and related information. A Data Set contains one or more Data Set Records (DSRs). CDF file products will also include the Specific Product Information from the Specific Product Header as global attributes. See Section 5.2.2 for details.

5.2 XML Header File

The XML Header file contains information identifying the product. It is composed by:

- a Fixed Header
- a Variable Header

The Fixed Header (hereafter called Standard Swarm Header) is the common header for all files in the Swarm Ground Segment, which means it is applied to all files flowing amongst the sub-systems composing the PDS.

The format of the Standard Swarm Header is under ESA responsibility and it is specified in [AD03] and [AD04].

The Variable Header (hereafter called Product Header) is the header with format and content depending on the file type and kind of product.

The next sub-paragraphs specify the content of these headers.

5.2.1 Level 1b Products Fixed Header (Standard Swarm Header)

The Standard Swarm Header is completely ASCII and based on XML syntax and conventions proposed in [AD03].

It has the same format as for the Level 0 products [AD02] with suitable settings for the Level 1b Processor:

Field	Content	Comment
File_Description	See Table 4-1, page 17	
Validity_Period.Validity_Start	Effective start time of product (time of first	In case of MAGXMAN_1B (Section 6.7), the validity stop

	data set record in product)	equals the validity start of the second ASM_VFM_IC record.
Validity_Period.Validity_Stop	Effective stop time of product (time of last data set record in product)	In the case of RINEX products, GPSX_R?_1B, the products follow the GPS days (and use GPS time in the RINEX product files), hence they start some seconds before UTC midnight; e.g. in 2013 GPS days start at 23:59:44 UTC.
Source.System	APDF	
Source.Creator	L1B	
Source.CreatorVersion	Job order verion	

5.2.2 Level 1b Products Variable Header (Product Header)

The XML Variable Header (hereafter called Product Header) for the Level 1b products is composed by:

- an XML Main Product Header (XML MPH)
- an XML Specific Product Header (XML SPH)

The XML MPH structure is common to all products while the XML SPH contains different information among the products.

Each header is completely ASCII and based on XML syntax and conventions proposed in the [AD03].

XML Main Product Header (XML MPH)

The Main Product Header (MPH) has the following format – very similar to the Level 0 Main Product Header [AD02], see also [AD04]:

Field #	Description	Units	Bytes[2]	Format
1	MPH	Tag		
1.1	Product	Tag		
	Product file name (without extension) See Section 5.3		55	55*uc

[2] Actually this column is redundant but listed for information only. Some field value lengths are not known, for these no information in "**Bytes**" column is given.

1.2	Proc_Stage_Code	Tag		
	Processing stage code: OPER = Routine operations TEST = Test RPRO = Re-processing		4	4*uc
1.3	Ref_Doc	Tag		
	Reference DFCB Document describing the product: SW-RS-DSC-SY-0007			*uc
Data Processing Information				
1.4	Acquisition_Station	Tag		
	Acquisition Station ID: KSS = Kiruna SGS = Svalbard		3	3*uc
1.5	Proc_Center	Tag		
	Processing Center ID code: FRB = Farnborough		3	3*uc
1.6	Proc_Time	Tag		
	Processing Time, UTC (Product Generation Time)		30	UTC=yyyy-mm-dd Thh:mm:ss.uuuuuu
1.7	Software_Version	Tag		
	Processor Name and software version number			*ProcessorName*/VV.rr (*uc)
Orbit Information				
1.8	Abs_Orbit_Start	Tag		
	Absolute orbit number at start of data. If not used set to "000000"		6	%06d
1.9	Abs_Orbit_Stop	Tag		
	Absolute orbit number at end of data. If not used set to "000000"		6	%06d
1.10	State_Vector_Time	Tag		
	UTC state vector time = sensing start time of product		30	UTC=yyyy-mm-dd Thh:mm:ss.uuuuuu
1.11	Delta_UT1	Tag		
	Universal Time Correction: DUT1 = UT1 – UTC. If not used set to "+0.000000"		9	%+9.6f
1.12	X_Position	Tag		

	X position in ECEF at start of product. If not used set to "+0000000.000"	m	12	%+012.3f
1.13	Y_Position	Tag		
	Y position in ECEF at start of product. If not used set to "+0000000.000"	m	12	%+012.3f
1.14	Z_Position	Tag		
	Z position in ECEF at start of product. If not used set to "+0000000.000"	m	12	%+012.3f
1.15	X_Velocity	Tag		
	X velocity in ECEF at start of product. If not used set to "+0000.000000"	m/s	12	%+012.6f
1.16	Y_Velocity	Tag		
	Y velocity in ECEF at start of product. If not used set to "+0000.000000"	m/s	12	%+012.6f
1.17	Z_Velocity	Tag		
	Z velocity in ECEF at start of product. If not used set to "+0000.000000"	m/s	12	%+012.6f
1.18	State_Vector_Source	Tag		
	Source of Orbit State Vector Record MD = Medium Precision Orbit Determination		2	2*uc
Product Confidence Data Information				
1.19	Product_Err	Tag		
	Product Error Flag. Set to 0 if all flags are within limits; set to 1 if any flag is above limit specified in CCDB, [RD03]		1	uc
Product Size Information				
1.20	Tot_Size	Tag		
	unit="bytes"	Attribute		
	Total size of product	bytes	21	%+021d
1.21	CRC	Tag		
	Cyclic Redundancy Code computed as overall value of all records of the Measurement Data Set. If not computed it shall be set to "-00001"		6	%+06d

Table 5-1 Level 1b Main Product Header (MPH)

XML Specific Product Header (XML SPH)

The formats of the Specific Product Headers (SPHs) are described next. The SPHs consist of a common part described first and small product specific parts described afterwards.

Field #	Description	Units	Bytes	Format
1	SPH	Tag		
1.1	SPH_Descriptor	Tag		
	Name describing the Product. "File Type" column of Table 4-1		10	10*uc
Information on Time and Orbits of Data				
1.2	Orbit_Information	Tag		
1.2.1	Sensing_Start	Tag		
	Start time in UTC of sensing data		30	UTC=yyyy-mm-dd Thh:mm:ss.uuuuuu
1.2.2	Sensing_Stop	Tag		
	Stop time in UTC of sensing data		30	UTC=yyyy-mm-dd Thh:mm:ss.uuuuuu
Maneuver Information – distinct maneuvers chronologically detected				
1.3	Maneuver_Information	Tag		
	count="n"	Attribute		
1.3.*i*	Maneuver_Id	Tag		
	The *i*th, distinct maneuver identification			
	Maneuver identification code, see [AD05]		3	%03d
Specific Product Information				
1.4	*The various products may have specific product information, see Table 5-3 through Table 5-10 below*			
Product Confidence Section – various information on the quality of the Product, such as number of missing or erroneous ISPs (Instrument Source Packets) and number of rejected or suspicious samples. Fields 1.5.2-1.5.4 are not used for MAGXMAN_1B				
1.5	Product_Confidence_Data	Tag		
1.5.1	Quality_Indicator	Tag		
	Generel product quality indicator		3	%03d
1.5.2	HK_ISP_Missing	Tag		
	Number of missing/erroneous platform HK ISPs		5	%05d

1.5.3	GPSR_ISP_Missing	Tag		
	Number of missing/erroneous GPSR ISPs		5	%05d
1.5.4	STR_ISP_Missing	Tag		
	Number of missing/erroneous STR ISPs		5	%05d
	Additional, Product specific fields are listed in Table 5-3 through Table 5-10 below. *Further fields may be added as needed.*			
Data Set Description Section				
1.6	List_of_DSDs	Tag		
	count=”n”	Attribute		
Data Set Descriptor – this part is repeated n *times, one for each Data Set (DS)*				
1.6.*i*	DSD	Tag		
	Data Set *i* descriptor, *i* = 1,2,…,n			
1.6.*i*.1	Data_Set_Name	Tag		
	Name of Data Set. If measurement data, Data Set Name (see Table 5-12). If reference file, File Type part of the referenced file (Section 4.1.3 of [AD04])			*uc
1.6.*i*.2	Data_Set_Type	Tag		
	Type of Data Set: M – measurement (e.g.MDR_Mag_HR) R – reference (see Section 5.2.3)		1	uc
1.6.*i*.3	File_Name	Tag		
	Name of referenced file; if CCDB file extension (“.EEF”) is included, otherwise without extension. Fill with blanks if Data_Set_Type ≠ “R”		55 or 59	55*uc or 59*uc
1.6.*i*.4	Data_Set_Offset	Tag		
	unit=”bytes”	Attribute		
	Offset (in bytes) of first byte of first DS record within Product File. Only used if Data_Set_Type = “M”, otherwise set to zeros.	Bytes	21	%+021d
1.6.*i*.5	Data_Set_Size	Tag		
	unit=”bytes”	Attribute		
	Total number of bytes in DS Only used if Data_Set_Type = “M”,	Bytes	21	%+021d

	otherwise set to zeros.			
1.6.*i*.6	Num_of_Records	Tag		
	Number of Data Set records Only used if Data_Set_Type = "M", otherwise set to zeros.		11	%+011d
1.6.*i*.7	Record_Size	Tag		
	unit="bytes"	Attribute		
	Size of Data Set records If variable set to –0000000001 Only used if Data_Set_Type = "M", otherwise set to zeros.	Bytes	11	%+011d
1.6.*i*.8	Byte_Order	Tag		
	Byte ordering information. 3210 → Big-endian 0123 → Little-endian Only used if Data_Set_Type = "M", otherwise set to "0000".		4	4*uc

Table 5-2 Level 1b Specific Product Header (SPH) – Common Part

The MAGX_HR_1B and MAGX_LR_1B Product SPHs shall contain the specific parts:

Field #	Description	Units	Bytes	Format
Magnetic Product Information				
1.4	Magnetic_Information	Tag		
1.4.1	q_STR_VFM	Tag		
	Quaternion from CRF (of STR) to VFM CCDB.Structure.**STR_q_VFM**			
1.4.1.*i*	Q*i* (*i* = 1,2,3,4)	Tag		
	i^{th} quaternion component		13	%+13.10f
1.4.2	r_CoG_VFM	Tag		
	Vector from S/C center of gravity to VFM, S/C frame			
1.4.2.*i*	X, Y, Z (*i* = 1,2,3 respectively)	Tag		
		m	6	%+6.3f

Product Confidence Section				
1.5.5	VFM_ISP_Missing	Tag		
	Number of missing/erroneous VFM ISPs		5	%05d
1.5.6	VFM_Samples_Rejected	Tag		
	Number of rejected VFM samples		7	%07d
1.5.7	VFM_Suspicious_Samples	Tag		
	Number of suspicious VFM samples		7	%07d
1.5.8	ASM_ISP_Missing	Tag		
	Number of missing/erroneous ASM ISPs MAGX_LR_1B Product only		5	%05d
1.5.9	ASM_Samples_Rejected	Tag		
	Number of rejected ASM samples MAGX_LR_1B Product only		5	%05d
1.5.10	ASM_Suspicious_Samples	Tag		
	Number of suspicious ASM samples MAGX_LR_1B Product only		5	%05d

Table 5-3 MAGX_HR_1B and MAGX_LR_1B SPH – Specific Parts

The ASMXAUX_1B and VFMXAUX _1B Product SPHs shall contain the specific parts:

Field #	Description	Units	Bytes	Format
Magnetic Product Information				
1.4	Magnetic_Stray_Fields	Tag		
1.4.1	VFM_q	Tag		
	Transformation from S/C to VFM sensor frame, CCDB.Structure.**VFM_q**			
1.4.1.*i*	Q*i* (*i* = 1,2,3,4)	Tag		
	*i*th quaternion component		13	%+13.10f
1.4.2	ASM_q_VFM			
	Transformation from VFM sensor to ASM sensor frame, CCDB.Structure.**ASM_q_VFM**			
1.4.2.*i*	Q*i* (*i* = 1,2,3,4)	Tag		
	*i*th quaternion component		13	%+13.10f
Product Confidence Section				
1.5.5	VFM_ISP_Missing	Tag		

	Number of missing/erroneous VFM ISPs		5	%05d
1.5.6	MTR_ISP_Missing	Tag		
	Number of missing/erroneous Magnetic Torquer HK ISPs		5	%05d
1.5.7	Bus_ISP_Missing	Tag		
	Number of missing/erroneous Bus Current HK ISPs		5	%05d

Table 5-4 ASMXAUX_1B and VFMXAUX_1B SPH – Specific Parts

The MAGX_CA_1B Product SPH shall contain the specific parts:

Field #	Description	Units	Bytes	Format
Magnetic Calibration Product Information				
1.4	Mag_C_Information	Tag		
1.4.1	ASM_Group_Delay	Tag		
	Group delay of ASM filter (CCDB.ASM.Filter.Delay)	s	7	%+7.4f
Product Confidence Section				
1.5.5	VFM_ISP_Missing	Tag		
	Number of missing/erroneous VFM ISPs		5	%05d
1.5.6	VFM_Samples_Rejected	Tag		
	Number of rejected VFM samples		7	%07d
1.5.7	VFM_Suspicious_Samples	Tag		
	Number of suspicious VFM samples		7	%07d
1.5.8	ASM_ISP_Missing	Tag		
	Number of missing/erroneous ASM ISPs		5	%05d
1.5.9	ASM_Samples_Rejected	Tag		
	Number of rejected ASM samples		5	%05d
1.5.10	ASM_Suspicious_Samples	Tag		
	Number of suspicious ASM samples		5	%05d

Table 5-5 MAGX_CA_1B SPH – Specific Parts

The MAGXMAN_1B Product SPH shall contain no specific Product Information parts.

The MODX_SC_1B, GPSX_RO_1B, and GPSX_RN_1B Product SPHs shall contain the specific Product Information part:

Field #	Description	Units	Bytes	Format
Position and RINEX Product Information				
1.4	Ephemeris_Information	Tag		
1.4.1	Mass_SC	Tag		
	Mass of the space craft at start of product	kg	7	%7.3f
1.4.2	r_CoG_ARP	Tag		
	Vector from center of gravity to antenna reference point, S/C frame	m	21	3 * " %+6.3f"
1.4.3	RINEX_Filename	Tag		
	Suggested name of RINEX file according to [RD01] (not to be confused with 1.6.*i*.3 – the *real* filename of the Product File). Eg. Ssssdddhmm.yyO Value for MODX_SC_1B Product: 'Not Appl.' (4 spaces between 'Not' and 'Appl.').		12	12*uc

Table 5-7 MODX_SC_1B, GPSX_RO_1B, and GPSX_RN_1B SPH – Specific Part

The GPSXNAV_1B Product SPH shall contain no specific Product Information parts.

The STRXATT_1B Product SPH shall contain the specific Product Information parts:

Field #	Description	Units	Bytes	Format
Attitude Product Information				
1.4	Attitude_Information	Tag		
Product Confidence Section				
1.5.5	STR_One_CHU_Missing	Tag		
	Number of attitude samples based on two camera heads (CHU)		5	%05d
1.5.6	STR_Two_CHU_Missing	Tag		
	Number of attitude samples based on one camera head only		5	%05d

Table 5-8 STRXATT_1B SPH – Specific Part

The EFIX_LP_1B, EFIXLPI_1B and LP_X_CA_1B, Product SPHs shall contain the specific Product Confidence part:

Field #	Description	Units	Bytes	Format
Plasma Product Information				
1.4	Plasma_Information	Tag		
Product Confidence Section				
1.5.5	EFI_ISP_Missing	Tag		
	Number of missing/erroneous TII & LP science ISPs		5	%05d
1.5.6	LP_ISP_Missing	Tag		
	Number of missing/erroneous (pure) LP ISPs		5	%05d

Table 5-9 EFIX_LP_1B SPH – Specific Part

The ACCX_PR_1B and SC_XDYN_1B Product SPH shall contain the specific Product Confidence part:

Field #	Description	Units	Bytes	Format
Acceleration Product Information				
1.4	Acceleration_Information	Tag		
Product Confidence Section				
1.5.5	ACC_ISP_Missing	Tag		
	Number of missing/erroneous ACC ISPs		5	%05d
1.5.6	ACC_Samples_Rejected	Tag		
	Number of rejected ACC samples		5	%05d

Table 5-10 ACCX_PR_1B and SC_XDYN_1B SPH – Specific Part

5.2.3 Input Files

Input files to the Level 1b Processor (Level 0, CCDB, and auxiliary files) used in the generation of the product are specified in the Data Set Descriptor (DSD) section of the SPH as "Reference" Data Sets – one DSD for each input file.

5.3 File Names

The file names of XML Header files and the ASCII file products (see Table 4-1) are defined in [AD04], that is:

MM_CCCC_TTTTTTTTT_yyyymmddThhmmss_YYYYMMDDTHHMMSS_vvv.HDR

MM_CCCC_TTTTTTTTT_yyyymmddThhmmss_YYYYMMDDTHHMMSS_vvv.sp3

or

MM_CCCC_TTTTTTTTT_yyyymmddThhmmss_YYYYMMDDTHHMMSS_vvv.rnx

where the meaning of the elements composing the file name is described in [AD04]. The start and stop times in the filename refer to sensing period (*Shape 1* in Section 4.1.5.1 of [AD04]).

The file names of the CDF file products (see Table 4-1) are a combination of the operational product file names and the MDR names (see Table 5-12) of the individual MDR types that compose that specific product:

MM_CCCC_TTTTTTTTT_yyyymmddThhmmss_YYYYMMDDTHHMMSS_vvv_<MDR_Name>.cdf

For example, in case of the MAGX_HR_1B magnetic Level 1b product with 50 Hz data for the Swarm satellite A the names could be:

SW_OPER_MAGA_HR_1B_20090624T075728_20090624T080231_0001.HDR

SW_OPER_MAGA_HR_1B_20090624T075728_20090624T080231_0001_MDR_MAG_HR.cdf

SW_OPER_MAGA_HR_1B_20090624T075728_20090624T080231_0001_ASM_VFM_IC.cdf

The file with the extension .HDR is the XML Header file and the file with the extension .cdf is the Level 1b product file.

Zipfiles containing ASCII file products are named:

MM_CCCC_TTTTTTTTT_yyyymmddThhmmss_YYYYMMDDTHHMMSS_vvv.ZIP

whereas zipfiles containing CDF file products are named:

MM_CCCC_TTTTTTTTT_yyyymmddThhmmss_YYYYMMDDTHHMMSS_vvv.CDF.ZIP

5.4 Product File

The Product File will consist of a

- Measurement Data Block

The Measurement Data Block contains a specific number of Data Sets as defined in Table 5-12 below.

File Type	Data Sets	Section	Number of records
MAGX_HR_1B	MDR_MAG_HR	6.1	0 – ~4,320,000
	ASM_VFM_IC	6.4	1
MAGX_LR_1B	MDR_MAG_LR	6.2	0 – 86,400
	ASM_VFM_IC	6.4	1
MAGX_CA_lB	MDR_MAG_CA	6.3	0 – 86,400
	ASM_VFM_IC	6.4	1
MAGXMAN_1B	VFM_MAN_RP	6.7	1
	ASM_VFM_IC	6.4	2
ASMXAUX_1B	MDR_ASMAUX	6.5	0 – ~4,320,000
VFMXAUX_1B	MDR_VFMAUX	6.6	0 – ~4,320,000
EFIX_LP_1B	MDR_EFI_LP	6.8	0 – 172,800
EFIXLPI_1B	MDR_EFILPI	6.9	0 – 86,400
LP_X_CA_1B	LP__OFF_CA	6.10	0 – 5
GPSX_RO_1B	MDR_GPS_RO	6.14	0 – 8,640
GPSX_RN_1B	MDR_GPS_RN	6.15	0 – 12
GPSXNAV_1B	MDR_NAVSP3	6.12	0 – 86,400
MODX_SC_1B	MDR_MODSP3	6.12	0 – 86,400
STRXATT_1B	MDR_SAT_AT	6.13	0 – 86,400
ACCX_PR_1B	MDR_ACC_PR	6.16	0 – 86,400
SC_XDYN_1B	MDR_SC_DYN	6.17	0 – 86,400

Table 5-12 Level 1b Data Sets

Each Data Set is build of Data Set Records with fixed record lengths, except for the MDR_GPS_RO and MDR_GPS_RN (RINEX) Data Sets which have variable record lengths.

The MDR_ID column of Table 5-12 lists the Data Set Record identifier values of the corresponding Data Set.

6. Details on Level 1b Product Data Set Records

This section contains the detailed definitions of the Swarm Level 1b Product Data Sets.

Generally, data are stored in binary format as signed or unsigned integers with suitable (decimal) scalings to accommodate the required range and resolution of the stored quantities. This provides a simple and efficient though flexible method of storing the data.

Latitude and longitude – provided as parts of geographical position information – ranges are symmetric around zero, i.e. latitude $\in$ [-90..+90] and longitude $\in$ [-180..+180].

The following sections contain Data Set Definition tables with the following entries:

<table>
<tr><th>Column</th><th>Description</th></tr>
<tr><td>FIELD</td><td>Field name</td></tr>
<tr><td>DESCRIPTION</td><td>Short description of the field</td></tr>
<tr><td>UNITS</td><td>Physical units of the field value:

eu = engineering units
m = meters
deg = degrees
as = arc seconds (1°/3600 ≈ 0.000278°)
nT = nano-Tesla (10^{-9} T)
C = degrees Celcius
s = seconds
UTC = Coordinated Universal Time
<blank> = no unit</td></tr>
<tr><td>DIM1</td><td>Dimensions of the stored values</td></tr>
<tr><td>TYPE</td><td>Type of stored integer value:
<table>
<tr><th>Type</th><th>Description</th><th>Range</th></tr>
<tr><td>CDF_UINT1</td><td>1 byte unsigned integer</td><td>0..255</td></tr>
<tr><td>CDF_INT2</td><td>2 byte signed integer</td><td>-32768..32767</td></tr>
<tr><td>CDF_UINT2</td><td>2 byte unsigned integer</td><td>0..65535</td></tr>
<tr><td>CDF_INT4</td><td>4 byte signed integer</td><td>-2147483648..
2147483647</td></tr>
<tr><td>CDF_UINT4</td><td>4 byte unsigned integer</td><td>0..4294967295</td></tr>
</table></td></tr>
</table>

6.1 Mag-H Data Set Record, MDR_MAG_HR

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation	UTC	1	CDF_EPOCH
SyncStatus	Time synchronization status (of VFM), source and quality, see Appendix D		1	CDF_UNIT2
Latitude	Position in ITRF – Geocentric latitude	deg	1	CDF_DOUBLE
Longitude	Position in ITRF – Geocentric longitude	deg	1	CDF_DOUBLE
Radius	Position in ITRF – Radius	m	1	CDF_DOUBLE
B_VFM	Magnetic field vector, VFM frame	nT	3	CDF_DOUBLE
B_NEC	Magnetic field vector, NEC frame, zero if Flags_q = 255	nT	3	CDF_DOUBLE
dB_Sun	Magnetic stray field correction vector of Sun induced stray field, VFM frame	nT	3	CDF_DOUBLE
dB_AOCS	Magnetic stray field correction vector of AOCS magneto-torquer coils, VFM frame	nT	3	CDF_DOUBLE
dB_other	Magnetic stray field correction vector of all other sources, VFM frame	nT	3	CDF_DOUBLE
B_error	Error estimates on magnetic field, VFM frame	nT	3	CDF_DOUBLE
q_NEC_CRF	Quaternion, transformation: NEC ← CRF		4	CDF_DOUBLE
Att_error	Error estimates on attitude information	mdeg	1	CDF_DOUBLE
Flags_B	Flags characterizing the magnetic field measurement, see Table 6-1		1	CDF_UNIT1
Flags_q	Flags characterizing the attitude information, see Table 6-1		1	CDF_UNIT1
Flags_Platform	Flags characterizing the S/C platform information, see Table 6-1		1	CDF_UNIT2

The values of the Flags_xxx fields of MDR_MAG_HR are given in the following table.

Flag	Value	Description
Flags_B	0	Magnetic field measurements (VFM) nominal
	1	ASM instrument turned off
	2	Outlier detected, gap, or not enough VFM temperature data for filtering
	3	Both conditions (values) 1 and 2 above
	4	Suspiciuos VFM sample
	5-7	Combination (sum) of values 1-4
	8	Discrepancy between ASM and VFM measurements
	10,12,14	Combination (sum) of values 2, 4, and 8
Flags_q	0	Attitude information (STR) nominal
	1	Lack of 1 or 2 attitudes of CHU1 in 4 nearest STR samples
	2	Lack of 1 or 2 attitudes of CHU2 in 4 nearest STR samples
	3	Lack of 1 or 2 attitudes of CHU3 in 4 nearest STR samples
	4	Lack of 3 or 4 attitudes of CHU1 in 4 nearest STR samples
	5	Lack of 3 or 4 attitudes of CHU2 in 4 nearest STR samples
	6	Lack of 3 or 4 attitudes of CHU3 in 4 nearest STR samples
	7	Not currently used
	8	On-ground aberrational correction of any attitude sample among 4 nearest STR samples.

Flag	Value	Description
	9-14	As 1-7 above with on-ground aberrational correction of any attitude sample among 4 nearest STR samples.
	15	Not currently used
	16	CHU1 obscured by bright object in 4 nearest STR samples (all 4 CHU1 samples invalid), CHU2 and CHU3 ok
	17	CHU2 obscured by bright object in 4 nearest STR samples (all 4 CHU2 samples invalid) , CHU1 and CHU3 ok
	18	CHU3 obscured by bright object in 4 nearest STR samples (all 4 CHU3 samples invalid) , CHU1 and CHU2 ok
	19	Lack of 2-4 attitudes of CHU1 and CHU2 in 4 nearest STR samples, but not both simultaneously
	20	Lack of 2-4 attitudes of CHU1 and CHU3 in 4 nearest STR samples, but not both simultaneously
	21	Lack of 2-4 attitudes of CHU2 and CHU3 in 4 nearest STR samples, but not both simultaneously
	22	Lack of 3-4 attitudes of CHU1, CHU2, and CHU3 in 4 nearest STR samples, but not two simultaneously
	23	Not currently used
	24-30	As 16-22 above with on-ground aberrational correction.
	31	Not currently used
	32	1 or 2 attitudes based on CHU1 alone (CHU2 and CHU3 missing) in 4 nearest STR samples
	33	1 or 2 attitudes based on CHU2 alone in 4 nearest STR samples
	34	1 or 2 attitudes based on CHU3 alone in 4 nearest STR samples
	35	2 attitudes based on single, intermittent CHU alone in 4 nearest STR samples
	36-39	Not currently used
	40-43	As 32-35 above with on-ground aberrational correction.
	44-47	Not currently used
	48	1 attitude sample missing among 4 nearest STR samples (data gap)
	49	2 attitude samples missing among 4 nearest STR samples
	50	3 or more attitude samples missing among 4 nearest STR samples
	51	3 or 4 attitudes based on CHU1 alone in 4 nearest STR samples
	52	3 or 4 attitudes based on CHU2 alone in 4 nearest STR samples
	53	3 or 4 attitudes based on CHU3 alone in 4 nearest STR samples
	54	3 or 4 attitudes based on single, intermittent CHU alone in 4 nearest STR samples

Flag	Value	Description
	55	Not currently used
	56-62	As 48-54 above with on-ground aberrational correction.
	63-254	Not currently used
	255	Not enough STR data for generating attitude information.
Flags_Platform	0	Platform telemetry nominal (no missing or suspicious data)
	1	Thruster latch valves open, thrusters not activated
	2	Thrusters activated
	4	Gap in Bus telemetry, 1 or 2 samples missing
	5-7	Used for combinations (sum) of values 1, 2, and 4
	8	Outlier detected in Bus currents
	9-15	Used for combinations (sum) of values 1-8
	16	Not enough data for filtering Bus currents (due to large gap or jump in data)
	17-31	Used for combinations (sum) of values 1-16
	32	Change in instrument state according to Bus telemetry
	33-63	Used for combinations (sum) of values 1-32
	64	No Bus telemetry available (for extended period)
	65-67	Used for combinations (sum) of values 1, 2 and 64
	128	Gap in AOCS telemetry
	129-195	Used for combinations (sum) of values 1-67 and 128
	256	Position information based on on-board (GPSR) navigational solution
	257-323 384-451	Used for combinations (sum) of values 1-67, 128, and 256

Table 6-1 Flag Values of MDR_MAG_HR

6.2 Mag-L Data Set Record, MDR_MAG_LR

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation	UTC	1	CDF_EPOCH
SyncStatus	Time synchronization status (of VFM), source and quality, see Appendix D		1	CDF_UINT2
Latitude	Position in ITRF – Geocentric latitude	deg	1	CDF_DOUBLE
Longitude	Position in ITRF – Geocentric longitude	deg	1	CDF_DOUBLE
Radius	Position in ITRF – Radius	m	1	CDF_DOUBLE
F	Magnetic field intensity, zero if Flags_F = 255	nT	1	CDF_DOUBLE
dF_Sun	Magnetic stray field correction of Sun induced stray field at ASM sensor	nT	1	CDF_DOUBLE
dF_AOCS	Magnetic stray field correction intensity of AOCS magneto-torquer coils	nT	1	CDF_DOUBLE
dF_other	Magnetic stray field correction intensity of all other sources	nT	1	CDF_DOUBLE
F_error	Error estimate on magnetic field intensity	nT	1	CDF_DOUBLE
B_VFM	Magnetic field vector, VFM frame, zero if Flags_B = 255	nT	3	CDF_DOUBLE
B_NEC	Magnetic field vector, NEC frame, zero if Flags_B = 255 or Flags_q = 255	nT	3	CDF_DOUBLE
dB_Sun	Magnetic stray field correction vector of Sun induced stray field at VFM sensor, VFM frame	nT	3	CDF_DOUBLE
dB_AOCS	Magnetic stray field correction vector of AOCS magneto-torquer coils, VFM frame	nT	3	CDF_DOUBLE
dB_other	Magnetic stray field correction vector of all other sources, VFM frame	nT	3	CDF_DOUBLE
B_error	Error estimates on magnetic field, VFM frame	nT	3	CDF_DOUBLE
q_NEC_CRF	Quaternion, transformation: NEC ← CRF		4	CDF_DOUBLE
Att_error	Error estimates on attitude information	mdeg	1	CDF_DOUBLE
Flags_F	Flags characterizing the magnetic field intensity measurement (F), see Table 6-2		1	CDF_UINT1
Flags_B	Flags characterizing the magnetic field vector measurement (B_VFM, B_NEC), see Table 6-2		1	CDF_UINT1
Flags_q	Flags characterizing the attitude information, see Table 6-1		1	CDF_UINT1
Flags_Platform	Flags characterizing the S/C platform information, see Table 6-1		1	CDF_UINT2
ASM_Freq_Dev	ASM frequency calibration data deviation		1	CDF_DOUBLE

The values of the Flags_q and Flags_Platform fields of MDR_MAG_LR are as for the MDR_MAG_HR given in Table 6-1; the values of Flags_F and Flags_B are given in the following table.

Flag	Value	Description
Flags_F	0	Magnetic field intensity measurements (ASM) nominal (scalar mode – normal or burst)
	1	ASM running in vector mode
	2	Outlier detected, gap, or not enough ASM frequency calibration data for filtering
	3	Combination (sum) of values 1 and 2
	4	At least one of 4 nearest ASM samples is suspicious
	5-7	Combination (sum) of values 1-4
	8	Within 8 seconds after ASM restart, loss of magnetic field lock, or telemetry

Flag	Value	Description
		gap
	9-15	Combination (sum) of values 1-8
	16	Discrepancy between ASM and VFM measurements – at least one of the 4 nearest ASM samples differ from VFM measurements
	17-31	Combination (sum) of values 1-16
	32	Gap in 4 nearest ASM samples
	33-63	Combination (sum) of values 1-32
	64	VFM instrument turned off, i.e. no stray field corrections
	65-79 96-111	Combination (sum) of value 64 with values 1-15 and 32-47
	255	Not enough ASM samples to generate F.
Flags_B	0	Magnetic field vector measurements (VFM) nominal
	1	ASM instrument turned off
	2	Outlier detected, gap, or not enough VFM temperature data for filtering
	3	Both conditions (values) 1 and 2 above
	4	More than 5 suspiciuos VFM samples in 2 seconds surrounding record time
	5-7	Combination (sum) of values 1-4
	8	Discrepancy between ASM and VFM measurements
	10,12,14	Combination (sum) of values 2, 4, 8
	16	Gap in VFM samples in surrounding 2 seconds (by rejection or missing data)
	17-24 26,28,30	Combination (sum) of values 1, 2, 4, 8, and 16 (but not 1 and 8 simultaneously)
	255	Not enough VFM samples to generate B_VFM and B_NEC

Table 6-2 Flags_F and Flags_B Values of MDR_MAG_LR

6.3 Mag-C Data Set Record, MDR_MAG_CA

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation	UTC	1	CDF_EPOCH
SyncStatus	Time synchronization status (of VFM), source and quality, see Appendix D		1	CDF_UINT2
Latitude	Position in ITRF – Geocentric latitude	deg	1	CDF_DOUBLE
Longitude	Position in ITRF – Geocentric longitude	deg	1	CDF_DOUBLE
Radius	Position in ITRF – Radius	m	1	CDF_DOUBLE
F	Magnetic field intensity, converted and corrected – *not* adjusted for filter group delay	nT	1	CDF_DOUBLE
dF_Sun	Magnetic stray field correction of Sun induced stray field at ASM sensor	nT	1	CDF_DOUBLE
dF_AOCS	Magnetic stray field correction intensity of AOCS magneto-torquer coils	nT	1	CDF_DOUBLE
dF_other	Magnetic stray field correction intensity of all other sources	nT	1	CDF_DOUBLE
F_error	Error estimate on magnetic field intensity	nT	1	CDF_DOUBLE
F_VFM	Magnetic field intensity from the VFM instrument, converted and corrected	nT	1	CDF_DOUBLE
B	Magnetic field vector, VFM frame, time $t^{shifted}$+dt	nT	3	CDF_DOUBLE
dB_Sun	Magnetic stray field correction vector of Sun induced stray field at VFM sensor, VFM frame, time $t^{shifted}$+dt_VFM	nT	3	CDF_DOUBLE
dB_AOCS	Magnetic stray field correction vector of AOCS magneto-torquer coils, VFM frame, time $t^{shifted}$+dt_VFM	nT	3	CDF_DOUBLE
dB_other	Magnetic stray field correction vector of all other sources, VFM frame, time $t^{shifted}$+dt_VFM	nT	3	CDF_DOUBLE
B_pre	Pre-calibrated VFM magnetic field vector, VFM frame, time $t^{shifted}$+dt_VFM	nT	3	CDF_DOUBLE
EU_VFM	Raw VFM measuremet, time $t^{shifted}$+dt_VFM	eu	3	CDF_DOUBLE
T_CDC	Temperature of VFM CDC, time $t^{shifted}$+dt_VFM	°C	1	CDF_DOUBLE
T_CSC	Temperature of VFM CSC, time $t^{shifted}$+dt_VFM	°C	1	CDF_DOUBLE
T_EU	Temperature of VFM EU, time $t^{shifted}$+dt_VFM	°C	1	CDF_DOUBLE
dt_VFM	Time offset of VFM measurement	s	1	CDF_DOUBLE
alpha	Solar inclination angle, rotation about –y axis, S/C frame, time $t^{shifted}$+dt_VFM	deg	1	CDF_DOUBLE
beta	Solar inclination angle, angle to –y axis, S/C frame, time $t^{shifted}$+dt_VFM	deg	1	CDF_DOUBLE

6.4 TCF.VFM Parameter Data Set Record, ASM_VFM_IC

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation	UTC	1	CDF_EPOCH
Timestamp_end	Time of last observation	UTC	1	CDF_EPOCH
Primary_EU	Id of active VFM DPU, 1 = primary, 3 = secondary		1	CDF_INT4
Bias	Vector of estimated offsets	nT	3	CDF_DOUBLE
Scale	Vector of estimated sensitivities		3	CDF_DOUBLE
Non_orth	Vector of estimated non-orthogonalities	mdeg	3	CDF_DOUBLE
Samples	Number of samples used in estimation		1	CDF_UINT4
Rms	Weighted rms value of residuals after estimation	nT	1	CDF_DOUBLE
Cov_row1	Covariances of estimated parameters – lower left part of covariance matrix – row 1		1	CDF_DOUBLE
Cov_row2	Covariances of estimated parameters – lower left part of covariance matrix – row 2		2	CDF_DOUBLE
Cov_row3	Covariances of estimated parameters – lower left part of covariance matrix – row 3		3	CDF_DOUBLE
Cov_row4	Covariances of estimated parameters – lower left part of covariance matrix – row 4		4	CDF_DOUBLE
Cov_row5	Covariances of estimated parameters – lower left part of covariance matrix – row 5		5	CDF_DOUBLE
Cov_row6	Covariances of estimated parameters – lower left part of covariance matrix – row 6		6	CDF_DOUBLE

Cov_row7	Covariances of estimated parameters – lower left part of covariance matrix – row 7		7	CDF_DOUBLE
Cov_row8	Covariances of estimated parameters – lower left part of covariance matrix – row 8		8	CDF_DOUBLE
Cov_row9	Covariances of estimated parameters – lower left part of covariance matrix – row 9		9	CDF_DOUBLE
W_scale	Log (base 10) values of actual scaling of weigths of a-priori information		9	CDF_DOUBLE

6.5 ASMXAUX_1B Data Set Record, MDR_ASMAUX

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation	UTC	1	CDF_EPOCH
SyncStatus	Time synchronization status (of VFM), source and quality, see Appendix D		1	CDF_UINT2
dB_Sun	Magnetic stray field vector of Sun induced stray field at ASM sensor, ASM frame	nT	3	CDF_DOUBLE
dB_AOCS	Magnetic stray field vector of AOCS magneto-torquer coils, ASM frame	nT	3	CDF_DOUBLE
dB_Thrust	Magnetic stray field vector of AOCS thruster activations, ASM frame	nT	3	CDF_DOUBLE
dB_Battery	Magnetic stray field vector of battery currents, ASM frame	nT	3	CDF_DOUBLE
dB_SP	Magnetic stray field vector of solar panels currents, ASM frame	nT	3	CDF_DOUBLE
dB_Bus	Magnetic stray field vector of S/C bus currents, ASM frame	nT	3	CDF_DOUBLE
dB_VFM	Magnetic stray field vector of VFM sensor, ASM frame	nT	3	CDF_DOUBLE
dB_Static	Static magnetic stray field vector of S/C platform, ASM frame	nT	3	CDF_DOUBLE
dB_Ind	Magnetically induced stray field vector of S/C platform, ASM frame	nT	3	CDF_DOUBLE
dB_State	Instrument and sub-system state dependent magnetic stray field vector, ASM frame	nT	3	CDF_DOUBLE

6.6 VFMXAUX_1B Data Set Record, MDR_VFMAUX

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation	UTC	1	CDF_EPOCH
SyncStatus	Time synchronization status (of VFM), source and quality, see Appendix D		1	CDF_UINT2
dB_Sun	Magnetic stray field correction vector of Sun induced stray field at VFM sensor, VFM frame	nT	3	CDF_DOUBLE
dB_AOCS	Magnetic stray field vector of AOCS magneto-torquer coils, VFM frame	nT	3	CDF_DOUBLE
dB_Thrust	Magnetic stray field vector of AOCS thruster activations, VFM frame	nT	3	CDF_DOUBLE
dB_Battery	Magnetic stray field vector of battery currents, VFM frame	nT	3	CDF_DOUBLE
dB_SP	Magnetic stray field vector of solar panels currents, VFM frame	nT	3	CDF_DOUBLE
dB_Bus	Magnetic stray field vector of S/C bus currents, VFM frame	nT	3	CDF_DOUBLE
dB_STR	Magnetic stray field vector of STR CHUs, VFM frame	nT	3	CDF_DOUBLE
dB_Static	Static magnetic stray field vector of S/C platform, VFM frame	nT	3	CDF_DOUBLE
dB_Ind	Magnetically induced stray field vector of S/C platform, VFM frame	nT	3	CDF_DOUBLE
dB_State	Instrument and sub-system state dependent magnetic stray field vector, VFM frame	nT	3	CDF_DOUBLE

6.7 MAGXMAN_1B Data Set Record, VFM_MAN_RP

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation	UTC	1	CDF_EPOCH
delta_t	Time difference between first observation in the two ASM_VFM_IC records	s	1	CDF_DOUBLE
delta_bias	Differences in estimated offsets	nT	3	CDF_DOUBLE
delta_scale	Differences in estimated scale values		3	CDF_DOUBLE
delta_non orth	Differences in estimated non-orthogonality angles	mdeg	3	CDF_DOUBLE
Threshold1_bias	Threshold 1 value, bias	nT	1	CDF_DOUBLE
Threshold1_scale	Threshold 1 value, scale		1	CDF_DOUBLE
Threshold1_non-orth	Threshold 1 value, non-orthogonality	mdeg	1	CDF_DOUBLE
Threshold2_bias	Threshold 2 value, bias	nT	1	CDF_DOUBLE
Threshold2_scale	Threshold 2 value, scale		1	CDF_DOUBLE
Threshold2_non-orth	Threshold 2 value, non-orthogonality	mdeg	1	CDF_DOUBLE
Messages	Number of messages, the **Message_ID** field below is repeated **Messages** times		1	CDF_INT4
Secondary structures				
Message_ID	Message id, see Table 6-3 below		1	CDF_INT4

The values of Message_ID are given in the following table.

Value	Description
1	All changes within threshold1. CCDB remains unchanged.
10	All changes within threshold2, at least one change above threshold1. CCDB parameters to be updated with linear change in time.
100	At least on change above threshold2. Furhter investigations needed. CCDB remains unchanged until further notice.
TBD	*Additional messages, warnings, and errors*

Table 6-3 VFM_MAN_RP Message_ID Values

6.8 EFI LP Data Set Record, MDR_EFI_LP

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Timestamp of the LP measurement	UTC	1	CDF_EPOCH
SyncStatus	Time synchronization status (of LP), source and quality, see Appendix D		1	CDF_UINT2
Latitude	Position in ITRF – Geocentric latitude	deg	1	CDF_DOUBLE
Longitude	Position in ITRF – Geocentric longitude	deg	1	CDF_DOUBLE
Radius	Position in ITRF – Radius	m	1	CDF_DOUBLE
U_orbit	Magnitude of spacecraft velocity in the ITRF	m/s	1	CDF_DOUBLE
Ne	Plasma density (electron)	cm^{-3}	1	CDF_DOUBLE
Ne_error	Error of the plasma density estimate	cm^{-3}	1	CDF_DOUBLE
Te	Plasma electron temperature	K	1	CDF_DOUBLE
Te_error	Error of the electron temperature estimate	K	1	CDF_DOUBLE
Vs	Spacecraft potential	V	1	CDF_DOUBLE
Vs_error	Error of the spacecraft potential estimate	V	1	CDF_DOUBLE
Flags_LP	Flags indicating the source of measurements, see Table 6-4		1	CDF_UINT1
Flags_Ne	Flags characterizing the plasma density measurement, see Table 6-4		1	CDF_UINT1
Flags_Te	Flags characterizing the electron temperature measurement, see Table 6-4		1	CDF_UINT1
Flags_Vs	Flags characterizing the spacecraft potential measurement, see Table 6-4		1	CDF_UINT1

The flags of the LP measurements are defined in the following table:

Table 6-4 Flags of the LP Measurements

Flag	Value	Description
Flags_LP	1	High gain probe has no errors
	3	High gain probe has errors, instead partially the low gain probe was used. See Flags_Te for implications.
	9	Data is from duplicated harmonic mode because of on-going sweep, it is recommended to discard these duplicate data
Flags_Ne	10	Nominal data, calibration error for this sample is computed
	19	Nominal data, but calibration error not computed/out of range
	20	Nominal data, error for this sample is not computed
	30	The estimate is from low gain probe, N_e estimate probably has a larger random error than the nominal high gain probe
	40	Negative density (high positive values, even extremes, are not flagged)
Flags_Te	10	Nominal data, calibration error for this sample is computed
	19	Nominal data, but calibration error not computed/out of range
	20	Nominal data, error for this sample is not computed
	12	Calibration error for this sample is computed, but ADC overflow at the linear bias, high gain probe, tracking ok, but discard T_e is recommended
	15	Calibration error for this sample is computed, but ADC overflow at the linear bias, low gain probe, tracking ok, but discard T_e is recommended
	22	Error for this sample is not computed, ADC overflow at the linear bias, high

Flag	Value	Description
		gain probe, tracking ok, but discard T_e is recommended
	25	Error for this sample is not computed, ADC overflow at the linear bias, low gain probe, tracking ok, but discard T_e is recommended
	32	Failed tracking, high gain probe, discard T_e is recommended
	35	Failed tracking, low gain probe, discard T_e is recommended
	36	Extreme value, discard T_e is recommended
	40	Negative T_e value, discard T_e is recommended
	41	ADC overflow at the retarded bias, high gain probe, discard T_e is recommended
	44	Wrong bias order, discard T_e is recommended
	46	ADC overflow at the retarded bias, low gain probe, discard T_e
Flags_Vs	10	Nominal data, calibration error for this sample is computed
	20	Nominal data, error for this sample is not computed
	25	ADC overflow at the retard bias, discarding V_s is recommend
	26	ADC overflow at the linear bias, discarding V_s is recommend
	30	Failed tracking, discarding V_s is recommend
	33	Value of V_s is unreasonable, discarding V_s is recommended

6.9 EFI interpolated LP Data Set Records, MDR_EFILPI

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Exact UTC second of the interpolated LP measurement	UTC	1	CDF_EPOCH
SyncStatus	Time synchronization status (of LP), source and quality, see Appendix D		1	CDF_UINT2
Latitude	Position in ITRF – Geocentric latitude	deg	1	CDF_DOUBLE
Longitude	Position in ITRF – Geocentric longitude	deg	1	CDF_DOUBLE
Radius	Position in ITRF – Radius	km	1	CDF_DOUBLE
U_orbit	Magnitude of spacecraft velocity in the ITRF	m/s	1	CDF_DOUBLE
Ne	Plasma density (electron)	cm^{-3}	1	CDF_DOUBLE
Ne_error	Error of the plasma density estimate	cm^{-3}	1	CDF_DOUBLE
Te	Plasma electron temperature	K	1	CDF_DOUBLE
Te_error	Error of the electron temperature estimate	K	1	CDF_DOUBLE
Vs	Spacecraft potential	V	1	CDF_DOUBLE
Vs_error	Error of the spacecraft potential estimate	V	1	CDF_DOUBLE
Flags_LP	Flags indicating the source of measurements, see Table 6-4		1	CDF_UINT1
Flags_Ne	Flags characterizing the plasma density measurement, see Table 6-4		1	CDF_UINT1
Flags_Te	Flags characterizing the electron temperature measurement, see Table 6-4		1	CDF_UINT1
Flags_Vs	Flags characterizing the spacecraft potential measurement, see Table 6-4		1	CDF_UINT1

The flags of the interpolated LP measurements are defined in the following table:

Table 6-5 Flags of the interpolated LP Measurements

Flag	Value	Description
Flags_LP	1	High gain probe has no errors
	3	High gain probe had errors, instead the low gain probe had to be used. See Flags_Te for implications.
	7	Only one original data point was used due to sweep or error with a time stamp updated to a full UTC second. The flag values are for this data point
Flags_Ne	10	Nominal data, calibration error for this sample is computed
	19	Nominal data, but calibration error is not computed/out of range for at least one of the original data points.
	20	Nominal data, calibration error is not computed for both of the original data points.
	30	The estimate for one of the original data points is from the low gain probe. N_e estimate probably has a large random error
	31	The estimate for both data points is from the low gain probe. N_e estimate probably has a very large random error
	40	Negative density (high positive values, even extremes, are not flagged)
Flags_Te	10	Nominal data, calibration error for this sample is computed
	19	Nominal data, calibration error for at least one of the data points is not computed/out of range
	20	Nominal data, error for both data points is not computed
	12	Calibration error for this sample is computed, but at least one data point had ADC overflow at the linear bias, high gain probe, tracking ok, discard T_e is recommended
	15	Calibration error for this sample is computed, but at least one data point had ADC overflow at the linear bias, low gain probe, tracking ok, discard T_e is recommended
	22	Error is not computed, at least one data point had ADC overflow at the linear bias, high gain probe, tracking ok, discard T_e is recommended
	25	Error is not computed, at least one data point had ADC overflow at the linear bias, low gain probe, tracking ok, discard T_e is recommended
	32	Failed tracking, both data points, high gain probe, discard T_e is recommended
	35	Failed tracking, both data points, low gain probe, discard T_e is recommended
	36	Extreme value, both data points, discard T_e is recommended
	40	Negative T_e, both data points, discard
Flags_Vs	10	Nominal data, calibration error for this sample is computed

Flag	Value	Description
	20	Nominal data, error for both data points is not computed
	25	ADC overflow at the retarded bias, both data points, discarding V_s is recommend
	26	ADC overflow at the linear bias, both data points, discarding V_s is recommend
	32	Failed tracking, both data points, discarding V_s is recommend
	33	Value unreasonable, both data points, discarding is recommended

6.10 LP Offset Determination Data Set Records, LP__OFF_CA

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation	UTC	1	CDF_EPOCH
SyncStatus	Time synchronization status, source and quality, see Appendix D		1	CDF_UINT2
Probe1_I_Bias_Offset	Probe 1 current bias offset	V	1	CDF_DOUBLE
Probe1_I_Slope_Offset	Probe 1 current slope offset	V	1	CDF_DOUBLE
Probe1_I_Fit_Error	Probe 1 current sweep fit error	V	1	CDF_DOUBLE
Probe1_U_Bias_Offset	Probe 1 voltage bias offset	V	1	CDF_DOUBLE
Probe1_U_Slope_Offset	Probe 1 voltage slope offset	V	1	CDF_DOUBLE
Probe1_U_Fit_Error	Probe 1 voltage sweep fit error	V	1	CDF_DOUBLE
Probe2_I_Bias_Offset	Probe 2 current bias offset	V	1	CDF_DOUBLE
Probe2_I_Slope_Offset	Probe 2 current slope offset	V	1	CDF_DOUBLE
Probe2_I_Fit_Error	Probe 2 current sweep fit error	V	1	CDF_DOUBLE
Probe2_U_Bias_Offset	Probe 2 voltage bias offset	V	1	CDF_DOUBLE
Probe2_U_Slope_Offset	Probe 2 voltage slope offset	V	1	CDF_DOUBLE
Probe2_U_Fit_Error	Probe 2 voltage sweep fit error	V	1	CDF_DOUBLE
FP_I_Bias_Offset	Face Plate current bias offset	V	1	CDF_DOUBLE
FP_I_Slope_Offset	Face Plate current slope offset	V	1	CDF_DOUBLE
FP_I_Fit_Error	Face Plate current sweep fit error	V	1	CDF_DOUBLE
FP_U_Bias_Offset	Face Plate voltage bias offset	V	1	CDF_DOUBLE
FP_U_Slope_Offset	Face Plate voltage slope offset	V	1	CDF_DOUBLE
FP_U_Fit_Error	Face Plate voltage sweep fit error	V	1	CDF_DOUBLE
FP_I_offset	Face Plate current offset measurements	eu	32	CDF_INT2
FP_U_offset	Face Plate bias offset measurements	eu	32	CDF_INT2
P1_I_offset	Probe 1 current offset measurements	eu	32	CDF_INT2
P1_U_offset	Probe 1 bias offset measurements	eu	32	CDF_INT2
P1_ref_ADC2	Probe 1 reference ADC2	eu	32	CDF_INT2
P1_ground	Probe 1 ground	eu	32	CDF_INT2
P2_I_offset	Probe 2 current offset measurements	eu	32	CDF_INT2
P2_U_offset	Probe 2 bias offset measurements	eu	32	CDF_INT2
P2_ref_ADC2	Probe 2 reference ADC2	eu	32	CDF_INT2
P2_ground	Probe 2 ground	eu	32	CDF_INT2
P1_Slope	Probe 1 slope offset, determined on-board	V	1	CDF_DOUBLE
P1_Bias	Probe 1 bias offset, determined on-board	V	1	CDF_DOUBLE
P1_Error	Probe 1 sweep fit error, determined on-board	V	1	CDF_DOUBLE
P2_Slope	Probe 2 slope offset, determined on-board	V	1	CDF_DOUBLE
P2_Bias	Probe 2 bias offset, determined on-board	V	1	CDF_DOUBLE

FIELD	DESCRIPTION	UNITS	DIM	TYPE
P2_Error	Probe 2 sweep fit error, determined on-board	V	1	CDF_DOUBLE

6.12 Position and Velocity Data Set Records, MDR_NAVSP3 and MDR_MODSP3

These Data Set records forms ASCII files following the Extended Standard Product 3 Orbit Format (SP3-c), cf [RD05]. These files may be compressed thereby reducing their size significantly. The "Number of Records" in Table 5-12 refers to the number of observations in one SP3 file.

6.13 Attitude Data Set Record, MDR_SAT_AT

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation	UTC	1	CDF_EPOCH
SyncStatus	Time synchronization status (of STR), source and quality, see Appendix D		1	CDF_UINT2
q	Quaternion, transformation: ITRF ← S/C		4	CDF_DOUBLE
Flags_q	Flags characterizing the attitude information, see Table 6-1		1	CDF_UINT1
Maneuver_Id	Current maneuver identification code		1	CDF_UINT1

6.14 RINEX Observation Data Set Record, MDR_GPS_RO

These Data Set records forms the RINEX observations files according to [RD01]. The format is thouroughly described in this document, rinex300.pdf, in particular Section 2 and Appendix A.

6.15 RINEX Navigation Data Set Record, MDR_GPS_RN

These Data Set records deviate from the RINEX GPS navigation files defined in [RD01]. The format is thouroughly described in this document, rinex300.pdf, in particular Section 2 and Appendix A.

6.16 Acceleration Data Set Record, MDR_ACC_PR

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation		1	CDF_EPOCH
SyncStatus	Time synchronization status, source and quality, see Appendix D		1	CDF_UINT2
a	Non-gravitational, linear acceleration, partly converted, S/C frame	m/s^2	3	CDF_DOUBLE
a_ang	Angular acceleration, partly converted, S/C frame	rad/s^2	3	CDF_DOUBLE
p	Position of proof mass within cavity, ACC frame	m	3	CDF_DOUBLE
p_ang	Angular position of proof mass within cavity, ACC frame	rad	3	CDF_DOUBLE
Temp	Temperatures of ACC	°C	6	CDF_DOUBLE
VpLTC1043	Positive voltage of LTC1043	V	1	CDF_DOUBLE
VnLTC1043	Negative voltage of LTC1043	V	1	CDF_DOUBLE

FIELD	DESCRIPTION	UNITS	DIM	TYPE
U_pol	Polarization voltage	V	1	CDF_DOUBLE

6.17 Spacecraft Dynamics Data Set Record, MDR_SC_DYN

FIELD	DESCRIPTION	UNITS	DIM	TYPE
Timestamp	Time of observation	UTC	1	CDF_EPOCH
SyncStatus	Time synchronization status, source and quality, see Appendix D		1	CDF_UINT2
a_Sun	Acceleration due to Solar radiation pressure, S/C frame	m/s^2	3	CDF_DOUBLE
e_Sun	Direction to the Sun, unit vector, S/C frame		3	CDF_DOUBLE
m_SC	Actual mass of S/C	kg	1	CDF_DOUBLE
r_CoG	Center of Gravity, S/C frame	m	3	CDF_DOUBLE
A_head	Cross section area normal, front	m^2	3	CDF_DOUBLE
A_right	Cross section area normal, right (+Y)	m^2	3	CDF_DOUBLE
A_left	Cross section area normal, left (-Y)	m^2	3	CDF_DOUBLE
A_down	Cross section area normal, down	m^2	3	CDF_DOUBLE
K_Earth	Downward optical reflectivity normal	m^2	3	CDF_DOUBLE
P_Gas	Pressure of gas tanks	Pa	2	CDF_DOUBLE
T_Gas	Temperature of gas tanks	°C	2	CDF_DOUBLE
Flags_Platform	Flags characterizing the S/C platform information, see Table 6-6		1	CDF_UINT2
Flags_q	Flags characterizing the attitude information, see Table 6-1		1	CDF_UINT1
dt_thr	Thruster on-time in seconds (Start of on-time at "Timestamp"), field with 12 colmns (column 1 = ACT 1, … , column 9 = OCT1, …)	s	1	CDF_DOUBLE
thr_set	Flag indicating which thruster branch was active (= 0 for no thrusters powered, = 1 for main units powered, = 2 for redundant units powered, =3 for both main and redundant units powered)		1	CDF_UINT2
f_thr	Nominal thrust force of activated thrusters* (combined force), field with 3 columns	mN	3	CDF_DOUBLE
a_centr	Centrifugal acceleration of ACC proof mass, S/C frame	m/s^2	3	CDF_DOUBLE
a_GG	Gravity gradient acceleration of ACC proof mass, S/C frame	m/s^2	3	CDF_DOUBLE

Flag	Value	Description
Flags_Platform	0	Platform telemetry nominal
	4	Heater switching
	5,6	Combination (sum) of values 1 and 2 with 4
	8	Level 1a.Bus.State telemetry missing
	9,10	Combination (sum) of values 1 and 2 with 8
	16	Thruster firing
	17…26	Combination (sum) of values 1/2, 4/8 and 16
	32	Level 1a.AOCS.Thru_HK telemetry missing
	33…42	Combination (sum) of values 1/2, 4/8 and 32

Table 6-6 Acceleration Product Flags

Appendix A

Abbreviations and Acronyms

ACC	Accelerometer
AOCS	Attitude & Orbit Control Subsystem
ASM	Absolute Scalar Magnetometer
CoG	Center of Gravity
CRF	Common Reference Frame (of STR)
DCG	Document Contents Guidelines
DNSC	Danish National Space Center
DRL	Documents Requirements List
EADS	European Aeronautic Defence and Space
ECEF	Earth Centered Earth Fixed (reference frame)
EESS	End-to-End System Simulator
EFI	Electric Field Instrument
EPS	Electrical Power Subsystem
ESA	European Space Agency
eu	engineering unit
GNSS	Global Navigation Satelite System
GPS	Global Positioning System
GPSR	GPS/GNSS Receiver
ICRF	International Celestial Reference Frame
IGRF	International Geomagnetic Reference Field
ITRF	International Terrestrial Reference Frame
KO	Kick-Off
LP	Langmuir Probe
MOD	Medium precision Orbit Determination
NEC	North-East-Centre reference frame
N/A	Not Applicable
NaN	Not a Number
PDS	Payload Data Segment
PPS	Pulse per Second
SOW	Statement of Work
S/C	Spacecraft
SRD	System Requirements Document
STR	Star Tracker
TBC	To Be Confirmed
TBD	To Be Defined
TII	Thermal Ion Imager
UTC	Universal Time Coordinated
VFM	Vector Field Magnetometer
WGS	World Geodetic System

Appendix B
Reference Frames

B.1 Definitions

The table below summarises the definitions of the relevant Swarm reference frames.

Name	Origin	Orientation	Description
ASM	ASM sensor	X along boom axis (forward) Y along S/C Y Z downwards (tilted)	ASM sensor frame
CRF	VFM sensor	Aligned with S/C axes, but fixed w.r.t. optical bench	Common reference frame of the STR. See Section B.2 below
ICRF	Barycentre of Solar System	X towards Vernal Y towards Summer Z towards North (w.r.t. the Solar System)	Inertial, International Celestial reference frame
ITRF	Centre of Earth	X along Greenwich meridian Y along 90° E meridian Z towards North pole	International Terrestrial reference frame, ITRF2008, cf. http://www.iers.org/nn_10968/IERS/EN/DataProducts/ITRF/itrf.html
NEC	Reference position	N towards North E towards East C towards center of Earth	Local North-East-Center reference frame, position dependent. See Section B.3
S/C	Bottom centre of face-plate	X nominal flight direction Y sideways (“right”) Z downwards (nadir)	S/C reference frame
VFM	VFM sensor	Z along boom axis (backwards) Y along S/C Y X downwards (tilted)	VFM sensor frame
WGS84	Centre of Earth	X along Greenwich meridian Y along 90° E meridian Z towards North pole	World Geodetic System 1984 reference frame, cf. http://earth-info.nga.mil/GandG/publications/tr8350.2/wgs84fin.pdf (equal to ITRF within a few cm).

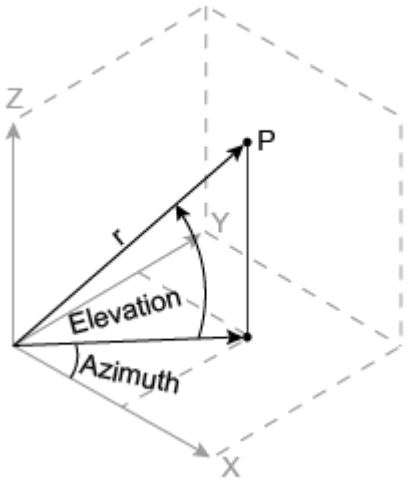
Spherical coordinates

Spherical coordinates are given as radius (r), elevation (θ), and azimuth (φ) as depicted in the figure on the right. The quantities may be computed as:

$$r = \sqrt{x^2+y^2+z^2}$$

$$\theta = \text{atan2}(z, \sqrt{x^2+y^2})$$

$$\varphi = \text{atan2}(y,x)$$



B.2 STR Common Reference Frame (CRF)

The common reference frame of the STR is fixed w.r.t. the optical bench with origin at the center of the VFM sensor and oriented in the general direction of the S/C frame, i.e. CRF_x is in the general flight direction, CRF_z is in the general nadir direction, and CRF_y forms a right handed system.

B.3 North East Center (NEC)

The NEC frame is defined in Section 3.7.2.3 of Swarm System Requirements Document, [SW-RS-ESA-SY-001]. At position **r**, the NEC frame unit vectors are:

$$\mathbf{e}_{\text{center}} = -\mathbf{r} / |\mathbf{r}| \quad \text{(B-10)}$$

$$\mathbf{e}_{\text{east}} = \begin{cases} \mathbf{a}/|\mathbf{a}|, \mathbf{a} = \mathbf{e}_{\text{center}} \times (0\,0\,1)^{\text{T}} \\ (0\,1\,0)^{\text{T}}, \text{if } |\mathbf{a}| = 0 \end{cases} \quad \text{(B-20)}$$

$$\mathbf{e}_{\text{north}} = \mathbf{e}_{\text{east}} \times \mathbf{e}_{\text{center}} \quad \text{(B-30)}$$

Hence, the rotation matrix, $R_{NEC \leftarrow ITRF}$, is (with **r** given in ITRF):

$$R_{NEC \leftarrow ITRF} = \begin{pmatrix} \mathbf{e}_{\text{north}} \\ \mathbf{e}_{\text{east}} \\ \mathbf{e}_{\text{center}} \end{pmatrix} \quad \text{(B-40)}$$

Appendix C

Example IGRF File

```
oersted_09d_04.cof, Oersted + CHAMP data 1999-2004, dark, crust removed, 30-Sep-2004 03:17:57
   ** Reserved for future use **
      8  max degree of quadratic secular variation
2002.00  epoch
     32  max degree of static field
     16  max degree of linear secular variation
      2  max degree of external field
6371.20  reference radius [km]
```

n	m	gnm	hnm	gdotnm	hdotnm	gddotnm	hddotnm
1	0	-29587.785	0	12.3073	0	-0.9000	0
1	1	-1705.180	5143.136	11.6053	-21.2673	-0.0156	-0.1349
2	0	-2296.091	0	-14.3520	0	0.1294	0
2	1	3061.769	-2526.360	-3.9579	-22.4875	-0.6080	-0.2172
2	2	1663.852	-479.603	-2.9051	-11.4992	0.4606	-0.5761
3	0	1336.438	0	-0.5842	0	0.0766	0
3	1	-2295.253	-216.253	-3.5149	5.4474	0.0334	0.1059
3	2	1249.891	285.204	-1.0965	-4.5673	0.0490	-0.4421
3	3	697.270	-508.135	-8.2284	-7.2957	0.2659	1.2031
4	0	927.340	0	-2.4409	0	-0.0399	0
4	1	791.093	276.057	2.1591	1.7843	0.1766	0.0506
4	2	234.149	-230.018	-7.8419	1.1842	0.1463	0.1885
4	3	-394.568	129.779	4.5517	5.1255	0.2698	0.0558
4	4	107.521	-304.354	-2.1248	-0.2732	-0.2107	0.0516
5	0	-221.656	0	-1.6969	0	-0.1572	0
5	1	352.516	43.353	0.6426	-0.2625	-0.0078	0.0398
5	2	217.183	174.849	-2.6525	1.5771	-0.0784	0.0846
5	3	-132.945	-128.965	-1.2856	1.9758	0.0560	-0.0564
5	4	-168.582	-31.900	0.0524	3.8856	0.0422	0.1486
5	5	-12.950	105.618	-0.2095	-0.4880	-0.1335	-0.1379
6	0	73.270	0	0.2342	0	-0.2619	0
6	1	68.728	-18.644	0.3214	-0.5918	-0.0320	0.0335
6	2	75.679	60.241	0.5646	-1.7616	-0.1705	-0.0399
6	3	-157.101	64.674	1.9321	-0.2828	0.0060	-0.0171
6	4	-9.204	-62.102	-1.7812	-0.4600	-0.0704	0.0234
6	5	15.979	0.382	-0.4035	-0.1701	-0.0017	0.0313
6	6	-89.104	46.692	0.7095	1.3996	0.1047	-0.0320
7	0	79.384	0	0.1173	0	-0.1600	0
7	1	-74.299	-63.107	-0.1114	0.6436	0.0351	-0.0026
7	2	-0.557	-23.528	-0.3109	0.3383	-0.0196	0.0026
7	3	35.439	6.572	1.0669	0.1317	0.0121	-0.0270
7	4	10.445	24.700	0.6554	0.3215	-0.0269	-0.0455
7	5	7.920	13.316	0.5090	-0.7582	-0.0042	-0.0170
7	6	6.656	-25.650	-0.3605	-0.2080	-0.0405	-0.0085
7	7	-0.216	-5.483	0.5971	0.1803	0.0949	0.0472
8	0	24.627	0	0.1051	0	-0.0956	0
8	1	7.095	11.632	0.2134	-0.1683	-0.0170	-0.0004
8	2	-10.254	-21.328	-0.4748	0.1313	0.0440	0.0218
8	3	-7.465	9.023	0.2178	0.2479	0.0051	-0.0051
8	4	-17.259	-20.824	-0.3127	0.3489	0.0349	0.0152
8	5	9.474	15.744	0.2050	0.1640	-0.0108	0.0121
8	6	7.874	8.388	0.4968	-0.2746	0.0212	-0.0188
8	7	-9.316	-14.174	-0.6970	0.4235	0.0422	0.0298
8	8	-6.302	-1.268	0.4057	0.3925	0.0533	-0.0152
9	0	5.257	0	0.0518	0		
9	1	9.560	-19.714	0.0425	-0.1022		
9	2	3.307	13.171	0.1214	-0.1259		
9	3	-7.852	12.554	0.2763	0.0470		
9	4	5.810	-6.443	-0.2577	-0.0839		
9	5	-9.638	-8.361	-0.3621	0.0260		
9	6	-1.446	8.269	0.0597	-0.0628		
9	7	9.034	3.425	-0.1090	-0.1709		
9	8	-5.272	-8.213	-0.4904	0.0476		
9	9	-8.571	5.396	-0.1880	0.2134		
10	0	-2.467	0	0.0940	0		
10	1	-6.015	1.882	-0.0329	0.1022		
10	2	1.597	0.062	-0.0037	0.0378		
10	3	-2.836	4.191	0.1447	0.0710		
10	4	-0.352	4.861	0.0556	-0.0394		
10	5	3.439	-6.173	-0.1362	-0.1495		
10	6	0.753	-1.130	-0.1608	0.0371		

10	7	2.043	-3.096	0.0207	-0.1322
10	8	4.144	-0.223	-0.1051	-0.2136
10	9	0.178	-2.228	-0.0807	-0.0378
10	10	-1.522	-7.700	-0.2246	-0.1250
11	0	2.834	0	0.0182	0
11	1	-1.702	0.301	0.0017	0.0180
11	2	-1.771	1.412	-0.0040	0.0407
11	3	1.507	-0.857	-0.0288	0.0395
11	4	-0.174	-2.485	-0.0307	0.0787
11	5	0.188	0.933	0.0361	-0.0137
11	6	-0.730	-0.672	-0.0172	0.0179
11	7	0.687	-2.752	-0.0479	0.0261
11	8	1.774	-0.974	0.0029	-0.0235
11	9	0.091	-1.302	0.0246	-0.0910
11	10	1.027	-1.970	-0.0344	-0.0185
11	11	4.025	-1.020	0.0184	-0.1593
12	0	-2.150	0	0.0054	0
12	1	-0.264	-0.435	0.0161	-0.0434
12	2	0.231	0.204	0.0431	-0.0025
12	3	0.849	2.429	0.0265	-0.0467
12	4	-0.250	-2.618	-0.0542	-0.0149
12	5	0.947	0.708	0.0005	-0.0198
12	6	-0.408	0.313	0.0308	0.0312
12	7	0.399	0.029	0.0296	0.0065
12	8	-0.333	-0.000	-0.0057	0.0091
12	9	-0.397	0.269	-0.0013	0.0123
12	10	-0.069	-0.894	0.0429	0.0148
12	11	-0.264	-0.470	-0.0740	0.0372
12	12	-0.292	0.936	0.1162	0.0761
13	0	-0.148	0	0.0068	0
13	1	-0.881	-0.769	-0.0202	0.0085
13	2	0.307	0.357	0.0067	0.0092
13	3	0.211	1.717	0.0321	0.0057
13	4	-0.409	-0.510	-0.0130	-0.0085
13	5	1.233	-1.005	-0.0076	-0.0214
13	6	-0.392	-0.059	-0.0009	0.0059
13	7	0.717	0.667	0.0040	-0.0107
13	8	-0.321	0.242	0.0251	-0.0171
13	9	0.302	0.587	0.0202	-0.0064
13	10	-0.053	0.347	0.0167	0.0212
13	11	0.396	-0.262	-0.0253	0.0243
13	12	0.078	-0.526	-0.1041	0.0185
13	13	-0.164	-0.823	-0.1702	-0.0890
14	0	-0.371	0	0.0171	0
14	1	0.320	0.366	0.0162	0.0084
14	2	-0.131	-0.707	0.0132	0.0051
14	3	-0.148	0.339	0.0011	-0.0105
14	4	-0.141	0.405	-0.0027	-0.0035
14	5	0.216	-0.052	-0.0075	0.0046
14	6	-0.079	0.368	0.0054	0.0047
14	7	-0.072	0.291	-0.0123	-0.0003
14	8	0.208	0.256	0.0087	-0.0175
14	9	-0.032	0.345	0.0112	0.0017
14	10	0.606	0.199	0.0307	-0.0062
14	11	-0.369	-0.007	-0.0068	0.0307
14	12	0.263	0.186	0.0233	-0.0270
14	13	0.218	-0.184	0.0251	-0.0120
14	14	0.311	-0.220	-0.0643	0.0759
15	0	0.187	0	0.0182	0
15	1	0.431	0.549	0.0079	0.0093
15	2	0.039	0.052	0.0054	0.0062
15	3	0.476	0.186	0.0082	0.0031
15	4	-0.076	0.065	-0.0023	-0.0005
15	5	0.095	-0.017	0.0025	0.0107
15	6	-0.127	0.054	-0.0053	0.0121
15	7	-0.163	0.271	0.0100	0.0094
15	8	0.137	-0.221	-0.0008	-0.0045
15	9	-0.257	0.089	-0.0079	0.0065
15	10	-0.206	-0.024	-0.0023	-0.0015
15	11	0.249	-0.091	-0.0162	-0.0075
15	12	0.002	-0.404	0.0076	0.0032
15	13	-0.153	0.185	0.0290	0.0187
15	14	0.079	0.065	0.0608	0.0277
15	15	-0.183	-0.062	-0.0260	0.0293
16	0	-0.104	0	0.0010	0

16	1	0.115	0.254	0.0238	-0.0025
16	2	-0.359	0.155	0.0052	-0.0250
16	3	0.122	0.268	-0.0052	-0.0114
16	4	0.009	-0.054	-0.0109	-0.0007
16	5	0.020	-0.096	-0.0009	0.0042
16	6	0.114	-0.055	-0.0034	0.0037
16	7	-0.037	-0.103	0.0048	-0.0009
16	8	0.210	0.002	-0.0036	0.0011
16	9	-0.223	-0.007	0.0032	0.0012
16	10	0.222	-0.150	0.0091	-0.0066
16	11	0.202	-0.051	-0.0079	-0.0013
16	12	0.025	-0.126	0.0118	-0.0038
16	13	-0.110	-0.123	0.0030	-0.0013
16	14	-0.213	0.172	0.0487	0.0041
16	15	-0.018	-0.057	-0.0795	0.0294
16	16	-0.141	-0.215	0.0187	-0.0161
17	0	-0.013	0	0	0
17	1	-0.007	0.080	0	0
17	2	-0.039	-0.251	0	0
17	3	0.351	-0.067	0	0
17	4	0.229	-0.112	0	0
17	5	-0.017	-0.216	0	0
17	6	0.046	-0.047	0	0
17	7	-0.075	-0.298	0	0
17	8	0.162	0.028	0	0
17	9	0.077	-0.045	0	0
17	10	0.015	-0.066	0	0
17	11	-0.162	0.130	0	0
17	12	-0.148	0.099	0	0
17	13	0.029	-0.053	0	0
17	14	0.069	-0.092	0	0
17	15	0.094	0.167	0	0
17	16	-0.014	-0.325	0	0
17	17	-0.165	-0.033	0	0
18	0	0.204	0	0	0
18	1	0.088	0.058	0	0
18	2	0.011	0.140	0	0
18	3	0.193	-0.045	0	0
18	4	-0.022	0.110	0	0
18	5	0.095	-0.050	0	0
18	6	0.181	0.087	0	0
18	7	-0.006	-0.204	0	0
18	8	0.041	-0.144	0	0
18	9	-0.069	-0.126	0	0
18	10	0.128	0.145	0	0
18	11	-0.023	0.097	0	0
18	12	-0.078	-0.121	0	0
18	13	-0.067	-0.031	0	0
18	14	-0.033	0.106	0	0
18	15	0.082	-0.090	0	0
18	16	-0.057	0.101	0	0
18	17	0.216	-0.127	0	0
18	18	-0.026	0.025	0	0
19	0	-0.020	0	0	0
19	1	0.410	0.110	0	0
19	2	-0.110	-0.001	0	0
19	3	0.093	-0.058	0	0
19	4	0.055	0.113	0	0
19	5	0.073	-0.330	0	0
19	6	-0.024	-0.003	0	0
19	7	0.108	-0.148	0	0
19	8	-0.013	-0.029	0	0
19	9	0.098	-0.049	0	0
19	10	-0.075	0.097	0	0
19	11	0.033	0.165	0	0
19	12	-0.098	0.002	0	0
19	13	-0.009	0.068	0	0
19	14	0.065	-0.083	0	0
19	15	0.125	0.092	0	0
19	16	0.060	-0.023	0	0
19	17	-0.072	-0.007	0	0
19	18	0.140	-0.113	0	0
19	19	-0.036	0.003	0	0
20	0	-0.078	0	0	0
20	1	0.225	0.021	0	0

20	2	-0.116	0.204	0	0
20	3	0.196	0.122	0	0
20	4	-0.157	-0.308	0	0
20	5	0.354	0.054	0	0
20	6	0.231	0.100	0	0
20	7	-0.078	0.115	0	0
20	8	-0.017	-0.174	0	0
20	9	0.034	-0.181	0	0
20	10	0.055	-0.062	0	0
20	11	-0.142	0.018	0	0
20	12	-0.013	0.004	0	0
20	13	-0.061	0.040	0	0
20	14	0.036	-0.133	0	0
20	15	-0.023	0.027	0	0
20	16	-0.003	0.087	0	0
20	17	-0.002	0.060	0	0
20	18	-0.099	0.142	0	0
20	19	-0.029	-0.004	0	0
20	20	-0.082	-0.116	0	0
21	0	-0.127	0	0	0
21	1	0.022	0.388	0	0
21	2	-0.119	0.032	0	0
21	3	0.187	0.139	0	0
21	4	-0.048	0.067	0	0
21	5	0.203	-0.200	0	0
21	6	-0.101	0.107	0	0
21	7	0.009	-0.124	0	0
21	8	-0.138	-0.153	0	0
21	9	0.063	-0.125	0	0
21	10	-0.097	-0.054	0	0
21	11	0.072	0.011	0	0
21	12	-0.042	-0.201	0	0
21	13	-0.057	-0.017	0	0
21	14	0.068	-0.064	0	0
21	15	0.036	-0.033	0	0
21	16	0.023	-0.162	0	0
21	17	-0.081	-0.101	0	0
21	18	-0.071	0.091	0	0
21	19	0.010	0.007	0	0
21	20	0.086	-0.025	0	0
21	21	0.043	-0.214	0	0
22	0	0.085	0	0	0
22	1	-0.059	0.130	0	0
22	2	-0.109	-0.076	0	0
22	3	0.069	0.355	0	0
22	4	-0.142	0.110	0	0
22	5	0.014	0.001	0	0
22	6	0.081	-0.068	0	0
22	7	-0.164	-0.029	0	0
22	8	0.026	-0.221	0	0
22	9	-0.160	-0.041	0	0
22	10	0.199	0.095	0	0
22	11	-0.055	-0.234	0	0
22	12	-0.133	-0.131	0	0
22	13	-0.008	0.106	0	0
22	14	0.108	-0.033	0	0
22	15	-0.055	-0.189	0	0
22	16	0.031	-0.118	0	0
22	17	-0.058	0.032	0	0
22	18	-0.121	-0.002	0	0
22	19	-0.015	0.007	0	0
22	20	0.031	0.046	0	0
22	21	0.058	0.034	0	0
22	22	0.090	0.040	0	0
23	0	0.216	0	0	0
23	1	0.090	0.246	0	0
23	2	-0.288	0.125	0	0
23	3	0.193	0.134	0	0
23	4	0.027	-0.156	0	0
23	5	-0.166	0.049	0	0
23	6	0.011	0.024	0	0
23	7	-0.019	-0.075	0	0
23	8	-0.185	-0.133	0	0
23	9	-0.210	-0.034	0	0
23	10	0.164	-0.033	0	0

23	11	0.110	0.155	0	0
23	12	0.182	-0.076	0	0
23	13	-0.232	-0.086	0	0
23	14	-0.056	0.256	0	0
23	15	0.068	-0.004	0	0
23	16	0.169	0.013	0	0
23	17	-0.004	0.038	0	0
23	18	0.036	0.012	0	0
23	19	-0.009	0.056	0	0
23	20	0.203	-0.033	0	0
23	21	0.109	-0.205	0	0
23	22	-0.011	-0.144	0	0
23	23	-0.084	0.079	0	0
24	0	-0.002	0	0	0
24	1	-0.043	-0.064	0	0
24	2	0.260	-0.114	0	0
24	3	0.027	0.027	0	0
24	4	0.004	-0.080	0	0
24	5	-0.050	0.075	0	0
24	6	0.190	0.094	0	0
24	7	0.076	0.090	0	0
24	8	0.289	0.154	0	0
24	9	-0.106	-0.226	0	0
24	10	0.012	0.150	0	0
24	11	0.217	0.199	0	0
24	12	0.142	0.048	0	0
24	13	0.115	0.050	0	0
24	14	-0.085	-0.008	0	0
24	15	-0.034	-0.010	0	0
24	16	0.084	0.168	0	0
24	17	0.077	0.093	0	0
24	18	-0.046	0.022	0	0
24	19	-0.003	0.112	0	0
24	20	-0.110	0.079	0	0
24	21	0.022	0.039	0	0
24	22	-0.031	-0.008	0	0
24	23	-0.056	0.008	0	0
24	24	-0.136	-0.100	0	0
25	0	0.216	0	0	0
25	1	0.051	0.117	0	0
25	2	-0.024	-0.269	0	0
25	3	0.156	0.213	0	0
25	4	0.119	0.158	0	0
25	5	-0.021	-0.014	0	0
25	6	0.154	-0.063	0	0
25	7	-0.155	0.245	0	0
25	8	0.003	0.194	0	0
25	9	0.091	0.243	0	0
25	10	0.130	-0.046	0	0
25	11	-0.011	0.048	0	0
25	12	0.166	0.302	0	0
25	13	0.229	0.054	0	0
25	14	-0.116	0.019	0	0
25	15	0.002	-0.096	0	0
25	16	0.097	-0.119	0	0
25	17	-0.015	0.249	0	0
25	18	0.256	0.071	0	0
25	19	0.053	-0.062	0	0
25	20	-0.056	-0.079	0	0
25	21	-0.027	-0.131	0	0
25	22	0.007	-0.011	0	0
25	23	-0.156	-0.113	0	0
25	24	-0.083	0.047	0	0
25	25	0.113	0.180	0	0
26	0	0.160	0	0	0
26	1	0.204	-0.102	0	0
26	2	-0.137	-0.339	0	0
26	3	-0.029	0.172	0	0
26	4	-0.011	0.217	0	0
26	5	-0.167	0.066	0	0
26	6	-0.089	-0.207	0	0
26	7	0.229	0.085	0	0
26	8	0.020	0.035	0	0
26	9	0.167	-0.035	0	0
26	10	-0.121	-0.040	0	0

26	11	0.117	0.166	0	0
26	12	0.278	0.006	0	0
26	13	-0.147	-0.034	0	0
26	14	-0.134	-0.073	0	0
26	15	0.128	-0.055	0	0
26	16	0.121	-0.213	0	0
26	17	0.001	0.031	0	0
26	18	0.038	0.090	0	0
26	19	0.108	-0.091	0	0
26	20	0.003	-0.051	0	0
26	21	-0.058	-0.087	0	0
26	22	0.022	0.090	0	0
26	23	0.040	-0.030	0	0
26	24	0.029	0.008	0	0
26	25	0.034	-0.173	0	0
26	26	0.012	0.036	0	0
27	0	0.295	0	0	0
27	1	0.074	0.263	0	0
27	2	-0.084	-0.185	0	0
27	3	0.173	0.016	0	0
27	4	-0.137	0.160	0	0
27	5	-0.084	0.120	0	0
27	6	0.109	-0.190	0	0
27	7	0.075	-0.055	0	0
27	8	-0.035	-0.016	0	0
27	9	0.073	0.254	0	0
27	10	0.048	-0.060	0	0
27	11	0.093	-0.010	0	0
27	12	0.115	-0.167	0	0
27	13	0.061	0.015	0	0
27	14	0.119	-0.071	0	0
27	15	0.004	0.006	0	0
27	16	0.059	0.008	0	0
27	17	0.055	-0.022	0	0
27	18	0.126	-0.009	0	0
27	19	-0.109	-0.060	0	0
27	20	-0.008	-0.094	0	0
27	21	-0.103	-0.145	0	0
27	22	-0.112	0.028	0	0
27	23	0.005	0.052	0	0
27	24	-0.100	0.111	0	0
27	25	-0.187	0.011	0	0
27	26	0.105	-0.002	0	0
27	27	-0.062	0.083	0	0
28	0	-0.151	0	0	0
28	1	0.206	0.132	0	0
28	2	-0.070	-0.190	0	0
28	3	-0.134	0.043	0	0
28	4	0.142	0.003	0	0
28	5	0.099	-0.018	0	0
28	6	-0.160	-0.060	0	0
28	7	0.101	0.220	0	0
28	8	0.119	-0.187	0	0
28	9	-0.073	0.113	0	0
28	10	-0.010	0.007	0	0
28	11	0.072	-0.022	0	0
28	12	-0.043	-0.017	0	0
28	13	0.049	-0.037	0	0
28	14	0.136	-0.022	0	0
28	15	0.045	0.083	0	0
28	16	0.016	-0.075	0	0
28	17	-0.002	0.043	0	0
28	18	-0.016	0.129	0	0
28	19	0.097	-0.066	0	0
28	20	-0.134	-0.166	0	0
28	21	-0.096	0.084	0	0
28	22	0.056	0.074	0	0
28	23	0.113	0.063	0	0
28	24	0.026	0.012	0	0
28	25	0.023	-0.036	0	0
28	26	-0.046	-0.096	0	0
28	27	-0.067	0.051	0	0
28	28	-0.205	0.020	0	0
29	0	0.048	0	0	0
29	1	0.110	-0.155	0	0

29	2	0.121	0.001	0	0
29	3	0.188	0.109	0	0
29	4	0.090	-0.022	0	0
29	5	0.075	0.038	0	0
29	6	-0.034	-0.196	0	0
29	7	-0.085	-0.065	0	0
29	8	0.130	-0.123	0	0
29	9	0.032	0.167	0	0
29	10	-0.079	-0.025	0	0
29	11	0.007	0.064	0	0
29	12	0.120	0.094	0	0
29	13	0.153	-0.077	0	0
29	14	0.014	-0.223	0	0
29	15	-0.053	0.095	0	0
29	16	0.184	-0.010	0	0
29	17	0.062	-0.108	0	0
29	18	-0.074	0.143	0	0
29	19	-0.014	0.066	0	0
29	20	0.016	-0.062	0	0
29	21	-0.048	0.067	0	0
29	22	-0.074	0.124	0	0
29	23	-0.011	0.036	0	0
29	24	-0.075	-0.036	0	0
29	25	-0.089	0.010	0	0
29	26	0.025	0.037	0	0
29	27	-0.297	0.072	0	0
29	28	0.240	0.034	0	0
29	29	-0.156	0.283	0	0
30	0	0.063	0	0	0
30	1	-0.046	0.150	0	0
30	2	0.182	-0.101	0	0
30	3	-0.362	-0.084	0	0
30	4	-0.077	0.096	0	0
30	5	0.226	-0.247	0	0
30	6	-0.028	-0.209	0	0
30	7	0.070	0.053	0	0
30	8	0.228	-0.248	0	0
30	9	0.129	0.039	0	0
30	10	0.028	0.043	0	0
30	11	0.073	-0.046	0	0
30	12	0.050	-0.119	0	0
30	13	0.206	0.131	0	0
30	14	0.065	0.028	0	0
30	15	0.024	-0.070	0	0
30	16	-0.024	-0.030	0	0
30	17	0.125	0.027	0	0
30	18	-0.022	0.044	0	0
30	19	-0.093	0.186	0	0
30	20	-0.009	0.073	0	0
30	21	-0.011	0.009	0	0
30	22	-0.066	0.019	0	0
30	23	0.067	0.054	0	0
30	24	0.086	0.043	0	0
30	25	0.079	-0.128	0	0
30	26	-0.085	-0.135	0	0
30	27	0.026	-0.131	0	0
30	28	0.119	0.025	0	0
30	29	-0.116	0.269	0	0
30	30	0.078	-0.372	0	0
31	0	-0.023	0	0	0
31	1	0.011	-0.067	0	0
31	2	-0.012	-0.039	0	0
31	3	-0.005	0.023	0	0
31	4	0.026	0.021	0	0
31	5	0.030	-0.011	0	0
31	6	-0.004	-0.002	0	0
31	7	0.031	-0.009	0	0
31	8	0.027	0.013	0	0
31	9	0.012	-0.004	0	0
31	10	-0.005	0.032	0	0
31	11	-0.002	-0.003	0	0
31	12	-0.045	0.008	0	0
31	13	0.034	0.019	0	0
31	14	0.017	-0.048	0	0
31	15	-0.033	0.017	0	0

31	16	0.010	-0.002	0	0
31	17	-0.041	-0.014	0	0
31	18	-0.023	0.005	0	0
31	19	0.003	0.051	0	0
31	20	-0.014	-0.021	0	0
31	21	0.037	-0.002	0	0
31	22	-0.027	0.016	0	0
31	23	0.004	0.011	0	0
31	24	-0.021	-0.004	0	0
31	25	-0.017	-0.008	0	0
31	26	-0.010	-0.052	0	0
31	27	-0.019	0.036	0	0
31	28	-0.148	0.052	0	0
31	29	0.027	-0.102	0	0
31	30	-0.077	-0.112	0	0
31	31	0.030	-0.463	0	0
32	0	0.083	0	0	0
32	1	0.055	-0.077	0	0
32	2	0.038	-0.010	0	0
32	3	-0.015	-0.043	0	0
32	4	-0.007	0.025	0	0
32	5	0.034	-0.060	0	0
32	6	-0.027	-0.042	0	0
32	7	-0.007	0.020	0	0
32	8	0.004	-0.001	0	0
32	9	-0.008	-0.025	0	0
32	10	-0.015	0.016	0	0
32	11	0.029	0.021	0	0
32	12	-0.017	-0.007	0	0
32	13	0.005	0.001	0	0
32	14	0.022	0.040	0	0
32	15	0.026	-0.041	0	0
32	16	0.033	0.021	0	0
32	17	0.002	-0.010	0	0
32	18	-0.014	0.015	0	0
32	19	0.018	0.002	0	0
32	20	0.028	-0.013	0	0
32	21	-0.006	-0.017	0	0
32	22	-0.014	-0.009	0	0
32	23	-0.009	0.015	0	0
32	24	-0.009	-0.006	0	0
32	25	0.003	-0.042	0	0
32	26	0.010	-0.018	0	0
32	27	-0.004	-0.033	0	0
32	28	-0.115	-0.028	0	0
32	29	0.129	0.119	0	0
32	30	-0.130	0.025	0	0
32	31	0.169	-0.094	0	0
32	32	-0.167	-0.269	0	0

Appendix D

Synchronization Status

The synchronization status field of the Level 1b Products, SyncStatus, provides information on the source and quality of the on-board time-stamp of the data. The values are defined in [AD05] and given below.

Value	Description
0	Time synchronized with on-board GPS receiver
1	Time information available, PPS (Pulse-Per-Second) *not* received
2	PPS received, time information *not* available
3	No time information, no PPS received
16	GPS out of synch, OBC (on-board computer) clock used
32	Synchronization in progress, inaccurate time information
48	Synchronization in progress, accurate time information
64	Synchronization with ground UTC in progress, inaccurate time information
80	Synchronization with ground UTC in progress, accurate time information
17…83	Combinations of values 1,2,3 and values 16,32,48,64,80

Table D-1 SyncStatus Values