Title: **Satellite Ancillary Data ICD**

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1. INTRODUCTION

1.1 Scope of the Document

Data provided from the space segment to support on-ground image data processing are called Ancillary Data. The following ancillary data are acquired and transmitted by the satellite. The EarthCARE ancillary data are composed of:

- ***Instrument Ancillary data*** produced by each individual instrument and directly included by the instrument in its instrument science packet data stream to the MMFU
- ***Satellite Ancillary data*** produced by the AOCS Application and provided as part of the HK data stream to the MMFU.

This documents defines the content of the ancillary data as needed for mission product generation. Description of other on-board acquired data, supporting orbit control, maintenance, status monitoring and observability in general are not addressed in by the document in hand.

1.2 References

1.2.1 Applicable Documents

[AD-01]	Astro APS - STR PUS ICD	APS-S2-ICD-JOP-2402
[AD-02]	EC Packet Utilization Standard	EC.STD.ASD.SY.00001
[AD-03]	GPSR Measurement Data I/F specification	S1-IF-AAE-SC-0002

1.2.2 Normative Documents

1.2.3 Reference Documents

[RD-01]	Abbreviation List	EC.LI.ASD.SY.00001
[RD-02]	Satellite Design Specification	EC.RS.ASD.SY.00005

1.3 Definitions

1.3.1 General Terms

In line with [RD-02], the following definitions apply:

Auxiliary Data

Supporting data sets provided outside the Space Segment data stream used to apply corrections to the Space Segment sensor data. Examples include: previously derived calibration parameters, ground control data, digital elevation data and GPS offset data.

Ancillary Data

Sum of instrument ancillary data and satellite ancillary data.

Instrument Ancillary Data

Data generated on-board by the instruments required for on-ground data processing in support to the observation data (e.g. detector blank pixels, blackbody temperature, optical and structural temperature, video electronics, detector temperature, etc...).

Satellite Ancillary Data

Data acquired on-board by the satellite in support of the observation data needed to process measurement data on ground containing at least the

- latest S/C State Vector provided to the instruments
- latest Attitude (Tattitude, quaternion)

The satellite ancillary data will be generated with an update frequency of 1 Hz."

S/C State Vector

The S/C State Vector will consist of:

- S/C State Vector quality field
- Nadir Pointing Performance Identifier (S/C is nadir pointing within a 1.5° (TBC) half cone to its geodetic sub-satellite point)
- Orbit State vector (Torb, position, velocity) w.r.t. ITRF
- Geodetic Altitude (Torb, Height)
- Orbit position (Torb, Argument of Latitude)

The S/C State Vector telecommand will be send to each instrument with an update frequency of 1 Hz. The S/C State Vector will be send at least 2s in advance before it's validity."

Housekeeping Data (HK Data)

Instrument or equipment telemetry to monitor modes, functional -, health status and performance if TM items available."

Measurement Data

Measurement data are raw - or processed data coming form the dedicated instrument detector, which will be extended by the detector / processing calibration data. The relevant scientific products processed on ground will be derived from the measurement - and ancillary"

On-Board Data Flow

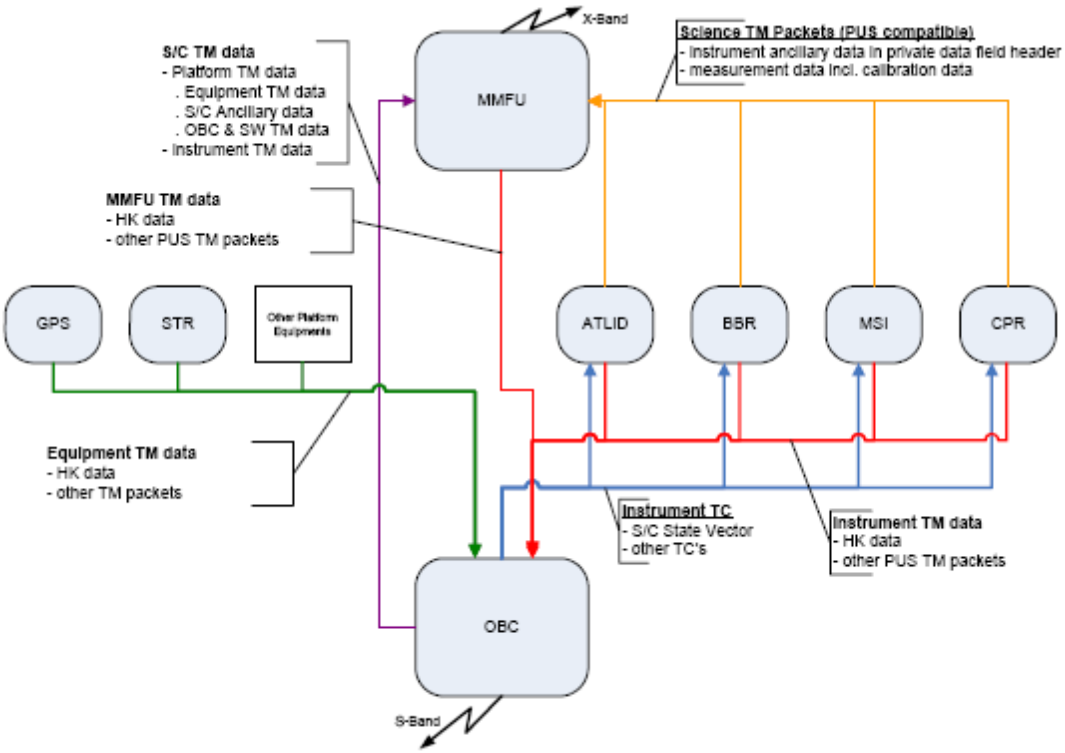

Figure 1.3-1 EarthCARE On-Board Data Flow

Ground Data Flow

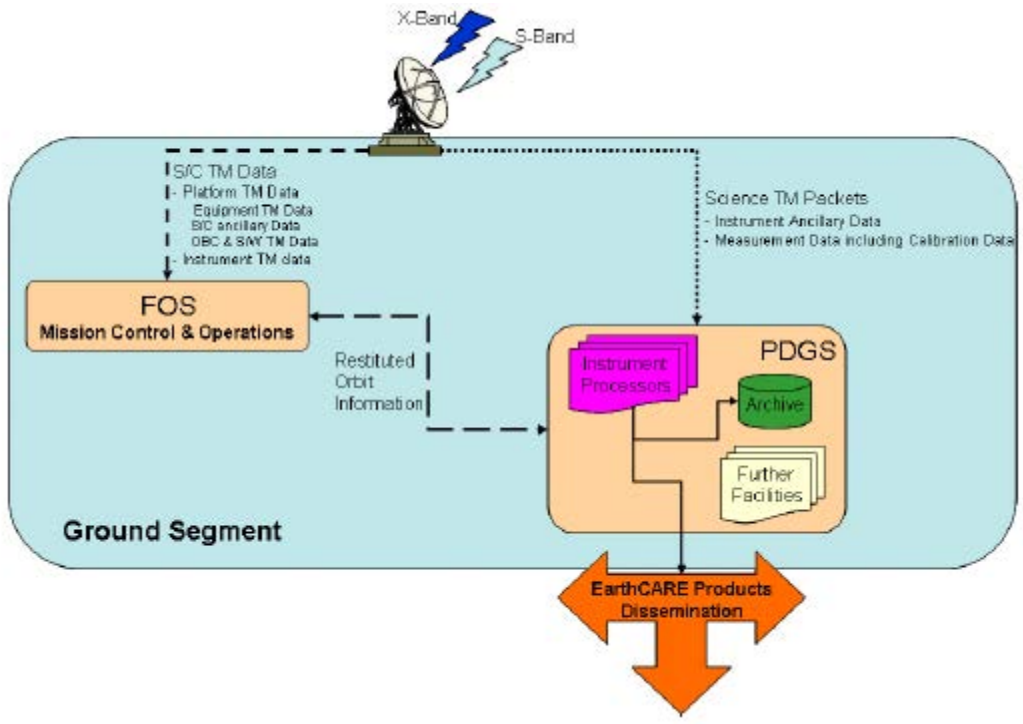

Figure 1.3-2 EarthCARE Ground Data Flow

1.4 Abbreviations

General EarthCARE abbreviations are in [RD-01].

Specific abbreviations used in this document are given below.

2. ANCILLARY DATA STRUCTURE

2.1 Ancillary Data Flow

Instrument Ancillary data are produced by each individual instrument and directly included by the instrument in its instrument science packet data stream to the MMFU

Satellite Ancillary data are produced by the System Control Application and provided as part of the HK data stream to the MMFU.

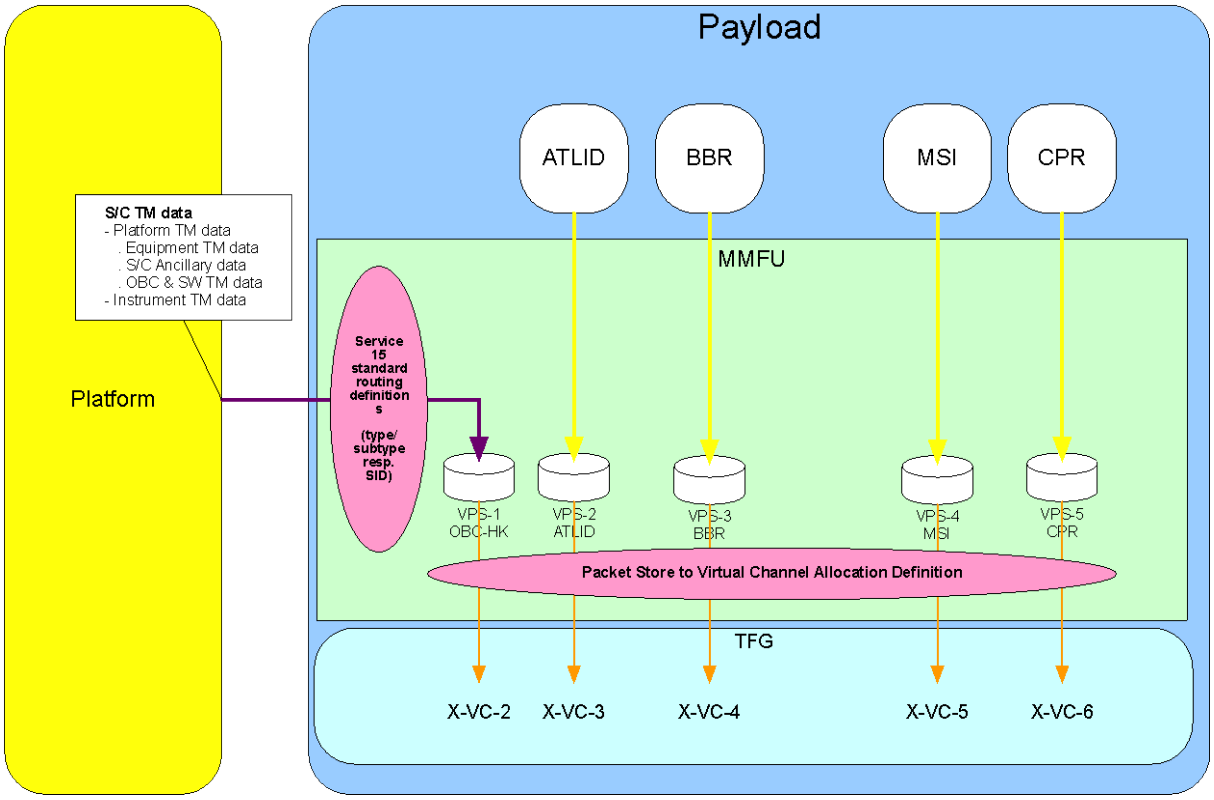

Figure 2.1-1: Ancillary data flow onboard EARTHCARE and relation to X-Band VC's

2.2 Instrument Ancillary Data

The instrument measurement data follow the standard PUS packet definition embedding a private extension of the data field header for inclusion of elementary instrument ancillary data. The embedded provision of instrument ancillary data as part of an extended header as well as directly in context with measurement data according to their repeat cycle is the preferred solution. In case higher rate instrument ancillary data are required for processing the individual measurement sample groups are started by a high rate instrument ancillary data group.

In case instrument ancillary data being part of the instrument science packets (ISP) would increase the data rate tremendously, provision of instrument ancillary data in dedicated instrument source packet as part of dedicated science service sub-type in the measurement data stream is tolerated.

For instrument science source packets the Source Data field consists a fixed, but instrument specific length Private Source Data Field Header and variable length measurement resp. calibration data.

This private source data field header is in addition to the standard data field header of the TM source packet.

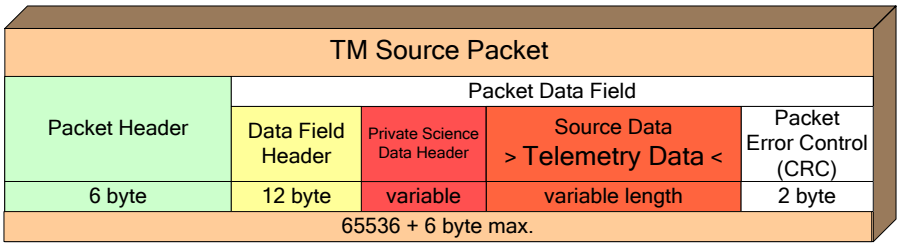

Figure 2.2-1 Instrument Science Source Packet (ISSP)

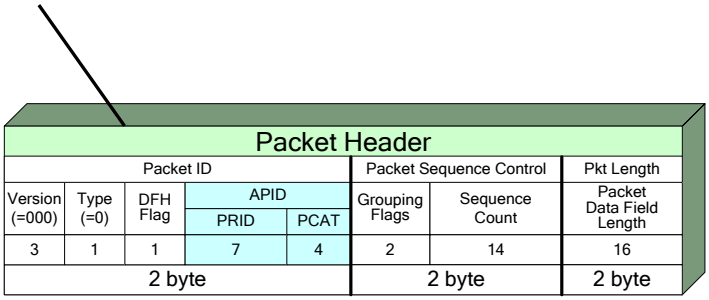

Figure 2.2-2: TM Source Packet Header

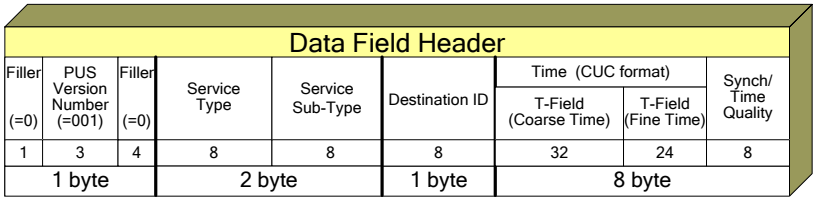

Figure 2.2-3: TM Packet Data Field Header

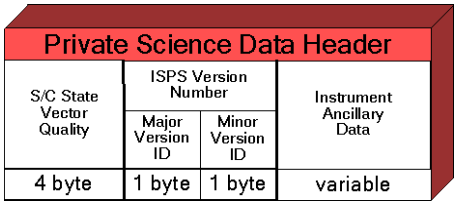

Figure 2.2-4: Private Science Data Header

Parameter	***Description***	***Range or value***
S/C State Vector Quality	Contains details about the S/C state vector quality information	See definition of field in service (145,128) in [AD-02]
ISPS version number	Contains a version number of ISP structure supporting evolution of its detailed definition	
Major Version ID		0-255

Parameter	*Description*	*Range or value*
Minor Version ID	This field represents the version number of the ISP structure definition. This version number shall be the same as the version number of the ICD defining the ISP format. The field shall be filled in as follows: The ISPFormatVersion field (2 Byte) in the Instrument Data Field Header shall store the version number of the ICD where the ISP format definition is specified. The most significant byte shall store the major version and the least significant byte shall store the minor version (e.g. the ICD with the version number 3.11 would result in MSByte=3 and LSByte=11 in the ISPFormatVersion field).	0-255
Instrument Ancillary Data	Any instrument data which may be used for processing of instrument measurement data	Instrument specific

Table 2.2-1: Private Science Data Header

Each instrument provides one dedicated science service according to [RD-02].

The service sub-types are allocated by the instruments individually reflecting the specific instrument needs. One sub-type for each required data format will be foreseen. In case of instrument sub-mode dependent science data formats one sub-type per instrument sub-mode should be allocated.

The instrument ancillary data are defined in the

2.3 Satellite Ancillary Data

The Satellite Ancillary Data are provided in SAT-NOM as TM(3,25) source packets according [AD-02].

All TM data,not only ancillary data, collected from units/instruments by the On-Board Computer (OBC) will be routed to a dedicated Satellite HK Data Store on the MMFU to allow transmission to ground via X-Band.

However, the same data can be retrieved via S-Band from the OBC mass memory packet stores. Here the storage configuration can be manged via PUS service 15. The default setting already ensures that the complete set of ancillary data is available via S-Band as well.

In general Satellite Ancillary Data are elementary composed of by the following entities:

- AOCS Mode, Nadir pointing performance
- AOCS propagated position and velocity with validity time PVT(Tpvt, PVT)
- Spacecraft position and velocity
- Spacecraft geodetic altitude and argument of latidude
- AOCS angular rates

A collection of these OBC aquired or computed data is regularly distributed to the EC instruments via service 145 as so called “Spacecraft State Vector”.

2.3.1 The Spacecraft State Vector

The S/C State Vector will consist of:

- S/C State Vector quality field
- Nadir Pointing Performance Identifier (S/C is nadir pointing within a 1.5° half cone to its geodetic sub-satellite point)
- Predicted Orbit State vector (Torb, position, velocity) w.r.t. ITRF
- Predicted Geodetic Altitude (Torb, Height)
- Orbit position (Torb, Argument of Latitude)

The spaceraft state vector data part of the ancillary data provides the latest parameter set, which has been sent to the instrumets. It is used by EarthCARE instruments to adjust measurement characteristics based on orbit position and/or altitude above the reference ellipsoid. The "Update S/C State Vector data" telecommand will be send to each instrument with an update frequency of 1 Hz. The S/C State Vector information will have a timestamp which ensures that the data are valid approximately 2s after receiption in the instrument.

Parameters of Application Data Field	*Length*	*Type*	*Description*	*Range or Value*
S/C State Vector Quality	32 bit	Enumerated	Indicates the validity status of the Local S/C Position Data	**Bit 0 (MSB) - Bit 7:** AOCS Mode&Sub-Mode; 0x00 = AOC_SBM 0x10 = AOC_ASM__DEP 0x11 = AOC_ASM___RD 0x12 = AOC_ASM___EA 0x13 = AOC_ASM___YA 0x14 = AOC_ASM___SS 0x15 = AOC_ASM__SEM 0x20 = AOC_NOM__DEP 0x21 = AOC_NOM__ACQ 0x22 = AOC_NOM___AH 0x23 = AOC_NOM___FP 0x24 = AOC_NOM___AM 0x31 = AOC_OCM__ACQ 0x32 = AOC_OCM__SL 0x33 = AOC_OCM_STAB 0x34 = AOC_OCM___DV 0x35 = AOC_OCM__BSL **Bit 8 to Bit 15:**

PARAMETERS OF APPLICATION DATA FIELD	*LENGTH*	*TYPE*	*DESCRIPTION*	*RANGE OR VALUE*
				OBC Sync Time Quality (see section 4.8 volume A of [AD-02]) **Bit 16 to Bit 29:** Spares not used so far **Bit 30:** Nadir Pointing Performance Identifier; 0 = Nominal Performance 1 = Degraded Performance **Bit 31**: (LSB) S/C State Vector Status; 0 = valid 1 = invalid
Time (local); Integer of Seconds	32 bit	Unsigned integer	Indicates the time in seconds at which the appended S/C State Vector Data become operative	0 to 2^{32} - 1 sec, LSB = 1 sec
Time (local); Subseconds	24 bit	Unsigned integer	Indicates the time in subseconds at which the appended S/C State Vector Data become operative	0 to 16777215 (1/16777215) sec, LSB = 59.6 nsec
Position X (local)	32 bit	Signed long integer	Indicates the value of the Local Spacecraft Position in X-direction to be updated	Unit: cm LSB = 1 cm Functional range: -7 000 E+5 to +7 000 E+5 cm w.r.t. to WGS 84 coordinate frame
Position Y (local)	32 bit	Signed long integer	Indicates the value of the Local Spacecraft Position in Y-direction to be updated	Unit: cm LSB = 1 cm Functional range: -7 000 E+5 to +7 000 E+5 cm w.r.t. to WGS 84 coordinate frame
Position Z (local)	32 bit	Signed long integer	Indicates the value of the Local Spacecraft Position in Z-direction to be updated	Unit: cm LSB = 1 cm Functional range: -7 000 E+5 to +7 000 E+5 cm w.r.t. to WGS 84 coordinate frame
Velocity X (local)	32 bit	Signed long integer	Indicates the value of the Velocity of the Local Spacecraft in X-direction to be updated	Unit: mm/s LSB = 1 mm/sec Functional range: -8 E+6 to +8 E+6 mm/sec w.r.t. to WGS 84 coordinate frame
Velocity Y (local)	32 bit	Signed long integer	Indicates the value of the Velocity of the Local Spacecraft in Y-direction to be updated	Unit: mm/s LSB = 1 mm/sec Functional range: -8 E+6 to +8 E+6 mm/sec w.r.t. to WGS 84 coordinate frame
Velocity Z (local)	32 bit	Signed long integer	Indicates the value of the Velocity of the Local Spacecraft in Z-direction to be updated	Unit: mm/s LSB = 1 mm/sec Functional range: -8 E+6 to +8 E+6 mm/sec w.r.t. to WGS 84 coordinate frame
Geodetic Altitude	32 bit	Signed long integer	Indicates the value of the geodetic altitude of the Local Spacecraft in Z-direction to be updated	Unit: cm LSB = 1 cm Functional range:0 to +7 000 E+5 cm w.r.t. to WGS 84 coordinate frame

PARAMETERS OF APPLICATION DATA FIELD	LENGTH	TYPE	DESCRIPTION	RANGE OR VALUE
Geodetic Argument of Latitude	32 bit	Signed long integer	Indicates the value of the argument of latitude of the local Spacecraft to be updated angle in [radians] x 10000	Unit: rad Numerical:full range LSB = $1E^{-4}$ rad Functional Range: $-\pi$ to $+\pi$

Table 2.3-1 S/C State Vector Parameter List

2.3.1.1 Spacecraft Attitude / Position

The following AOCS attitude and position data will be provided as part of the satellite ancillary data with a frequency of 1Hz.

The a subset of the data is part of the SSV. All other parameters are transmitted via TM(3,25). A future issue of this document will list the dedicated structure Id'a as well as the structure itself.

Since all SSV data are nominal HK's having parameter Id's assigned, it is possible to access it via the nominal PUS services as well. This will ensure a maximum level of observabiliy for the ancillary data generation and distroibution process.

2.3.1.1.1 S/C Attitude

(fully processed by AOCS, in terms of quaternions Piloting Frame to J2000 Inertial Frame (PJ), not propagated):

Parameter Name	Description	Type	Size	Unit	default
ssvTattCucRaw	Time of validity of spacecraft attitude data (CuC fomat) => part of SSV	Uint32	2	-	-
ssvAtt_qVec_PJ	Vector part of measured attitude quaternion in P-frame => part of SSV	Double	3	-	0,0,0
ssvAtt_qSca_PJ	Scalar part of measured attitude quaternion in P-frame => part of SSV	Double	1	-	1
strFusStatusId	STR quaternion fusion status ID 0: STR1/2 fused, fully valid; 1: STR 2 used, valid, 2: STR-1 used, valid, 3: invalid	uint8	1	-	-
ssvAttIsValid	Validity flag for fine attitude => part of SSV Note: it is recommended to use *strFusStatusId* instead of this parameter	boolean	1	-	-

Table 2.3-2 S/C Attitude Parameter List

2.3.1.1.2 S/C PVT

(fully processed by AOCS orbit propagator, using GPS input data, data with respect to J2000 Inertial Frame):

Parameter Name	Description	Type	Size	Unit	default
oopPos_J	Propagated position in J frame	double	3	m	0
oopPos_J	Propagated position in J frame	double	3	m	0
oopTimeSec	Time stamp of propagated output data	double	1	s	0
oopQualIdx	Oop solution quality index 0: invalid, 1: valid, but propagated and degraded, 3:valid with full accuracy	uint8	1	-	0
oopIsValid	Valid flag for orbit propagator function Note: it is recommended to use *oopQualIdx* instead of this parameter	boolean	1	-	false

Table 2.3-3 S/C PVT Parameter List

2.3.2 TM Packets from Startracker

The attidude data TM source data packets are provided from the preselected Startracker(s) (STR). The detailed definition of all STR data packets is given in [AD-01].

The STR TM packets are time stamped by the STR itself, which is synchronized with the Central OBT.

TM_ADB packet delivered at **10 Hz** contains the following information:

Rank	Level	Position	Length [byte]	Id	Name	Description
1	0	0	1	SST01000	SID_1	SID = 105
2	0	1	4	SST00001	qv1_1	vector part of attitude quaternion, x component
3	0	5	4	SST00002	qv2_1	vector part of attitude quaternion, y component
4	0	9	4	SST00003	qv3_1	vector part of attitude quaternion, z component
5	0	13	4	SST00004	qs_1	scalar part of attitude quaternion
6	0	17	2	SST00005	rateX_1	angular rate in BRF
7	0	19	2	SST00006	rateY_1	angular rate in BRF
8	0	21	2	SST00007	rateZ_1	angular rate in BRF
9	0	23	6	SST00008	TimeStamp_1	Time stamp of the center of integration associated with the attitude
10	0	29	2	SST00009	julianDate_1	Julian date used for precession correction (if enabled); specified in number of days since the epoch date of the built-in star catalog; day #0 c 2451545
11	0	31	2	SST00010	vVectorSciX_1	If aberration correction is enabled: X coordinate of velocity vector (in
12	0	33	2	SST00011	vVectorSciY_1	

Rank	Level	Position	Length [byte]	Id	Name	Description
13	0	35	2	SST00012	vVectorSciZ_1	SCI) 0 therw ise : 0
14	0	37	1	SSTG0001	GloPar1ADB_1	

Name	Description	Pos.	Lenth [bit]
SSTD0013	altitQuality_1	0	3
SSTD0014	isPrecCorr_1	3	1
SSTD0015	isAbberCorr_1	4	1
SSTD0016	rateQuality_1	5	2
SSTD0017	isValidRate_1	7	1

15	0	38	1	SST01017	attQualityIx_1	sum of single-star qualities of attitude stars

Table 2.3-4 STR TM_ ADB – Attidute Data Block

2.3.3 TM Packets from GPS-Receiver

The Navigation Solution Data Record TM source data packets are provided from the preselected GPS-Receiver (GPSR). The detailed definition of all GPSR measurement data packets is given in [AD-03]. The GPSR TM packets are time stamped by the GPSR itself, which is synchronized with the Central OBT.

The PVT data are time stamped with GPS time.

The navigation solution is delivered with **1Hz** and contains the following informationö:

- Navigation Solution Data Record
  - WGS84 Position (satellite center of mass) propagated to the most recent PPS
  - WGS84 Velocity propagated to the most recent PPS
  - GPS-Time of the most recent PPS
  - Quality index: GDOP, PDOP, TDOP

Rank	Level	Position	Length [byte]	Id	Name	Description
1	0	0	1	GST01627	SID	
2	0	1	3	GST01639	FILLER	
3	0	4	1	GST0163A	FE_TEMP	
4	0	5	1	GST0163B	ID	
5	0	6	1	GSTG02F2	SN_V_RMODE	
6	0	7	1	GST0163F	NOF_RECORD	
7	0	8	4	GST01640	GPST_SEC	GPS time
8	0	12	4	GST01641	GPST_SUBSEC	GPST representation of the synchronisation time stamp. GPS type definition see [CHKDIS].

Rank	Level	Position	Length [byte]	Id	Name	Description
9	**0**	**16**	**2**	**GSTG02F3**	**NU3_NSM_QUALIN**	
		Pos.	***Lenth [bit]***	***Id***	***Name***	***Description***
		0	1	GST01642	N_U_3	Not used
		1	3	GST01643	NSM	**Navigation Solution Method**
		4	12	GST01644	QUAL_INDEX	**Quality index in [m]** position quality index, values greater than 4095m are saturated to 4095m, details see [SUM]
1o	0	18	2	GST01645	GDOP	**Geometrical dilution of precision** 1 LSB corresponds to 10^{-2}; values greater than 655.34 are saturated to 65534 This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
11	**0**	**20**	**2**	**GSTG02F4**	**MAXURA_MAXFIT_NU**	
		Pos.	***Lenth [bit]***	***Id***	***Name***	***Description***
		0	5	GST01646	MAX_URA	**Maximum user range accuracy**
		5	4	GST01647	MAX_FIT	**Maximum curve fit interval** taken from all SVs used in current navigation solution
		9	3	GST01648	N_U_4	Not used
		12	4	GST01649	NOF_SV	**Number of SVs** contributing to the Navigation Solution
12	0	22	4	GST0164A	POS_X_MSB	**x,y,z coordinates in [mm]** in WGS84, see also [WGS84] Est position of the platform reference point (center of mass) according to the Navigation Solution Method (NSM) at the point in time of GPST. Note: In the SRDB definition these
13	0	26	2	GST0164B	POS_X_LSB	
14	0	28	4	GST0164C	POS_Y_MSB	
15	0	32	2	GST0164D	POS_Y_LSB	
16	0	34	4	GST0164E	POS_Z_MSB	

Rank	Level	Position	Length [byte]	Id	Name	Description
17	0	38	2	GST0164F	POS_Z_LSB	parameters are divided in one most significant 32 bits wide parameter POS_X/Y/Z_MSB and one 16 bits wide POS_X/Y/Z_LSB part. The aggregate parameter can be calculated as (C syntax): POS_X/Y/Z_MSB<<16 | POS_X/Y/Z_LSB
18	0	40	4	GST01650	VEL_X	**x,y,z-velocity in [mm/s]** in WGS84, see also [WGS84] Estimated velocity of the platform reference point (center of mass) according to the Navigation Solution Method (NSM) at the point in time of GPST.
19	0	44	4	GST01651	VEL_Y	
20	0	48	4	GST01652	VEL_Z	
21	0	52	2	GST01653	PDOP	**Position dilution of precision** 1 LSB corresponds to 10^{-2}, values greater than 65534 are saturated to 65534 This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
22	0	54	2	GST01654	TDOP	**Time dilution of precision** 1 LSB corresponds to 10^{-2}, values greater than 65534 are saturated to 65534 This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
23	0	56	4	GST01655	delta_x	**Position error in x,y,z direction [mm]** This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
24	0	60	4	GST01656	delta_y	
25	0	64	4	GST01657	delta_z	

Rank	Level	Position	Length [byte]	Id	Name	Description
26	0	68	4	GST01658	delta_t	**GNSS system time error in [ns]** This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
27	0	72	4	GST01659	delta_v_x	**Velocity error in x,y,z direction in [mm/s]** This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
28	0	76	4	GST0165A	delta_v_y	
29	0	80	4	GST0165B	delta_v_z	
30	0	84	4	GST0165C	delta_f	**Receiver clock frequency error in [mHz].** This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
31	0	88	4	GST0165D	HEIGHT	**Height w.r.t WGS-84 reference frame in [cm]**
32	0	92	4	GST0165E	VERTSPEED	**Vertical speed** w.r.t WGS-84 reference frame in [0.01mm/s]
33	0	96	4	GST0165F	LONGITUDE	**Longitude** w.r.t WGS-84 reference frame -90 degrees to +90 degrees in [1e-7deg]
34	0	100	4	GST01660	LATITUDE	**Lattidude** w.r.t WGS-84 reference frame -90 degrees to +90 degrees in [1e-7deg]

Table 2.3-5 GPS – Navigation Solution Data Record definition

ASTRIUM

EarthCARE
Routing Sheet

Doc. No.: EC.ICD.ASD.SY.00026
Issue: 1
Date: 01/08/13

Notes to Document Status:

ASD project limited..... ☐ ...

Transfer to Doc-office
from:
..... Name

via:
ftp-server: ☐
File-server: ☒
e-mail: ☐
paper: ☐
SPRINT ☐

ASD	review	Copy
Slansky, Uwe		x
Allgaier, Andreas		
Bayer, Thomas		
Beyer, Gerrit		
Bischoff, Uwe		
Bota, Sorin		
Brendle, Klaus		
Cataloglu, Aydin		
Da Costa, Andrea		
Dapp, Eric		
Del Rosario, Carlo		
Duske, Norbert		x
Faust, Thomas		
Felkel, Robert		
Ferraro, Leonora		
Fischbach, Anna		
Fischer, Jennifer		
Fischer, Tobias		
Gessler, Leo		
Gladel-Speicher, S.		
Gnirs, Patrick		
Gotsmann, Michael	x	x
Grasl, Andreas		
Guenthner, Klaus		
Häberle, Elisabeth		
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König, Hansjörg		
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Krovel, Trond		
Kruse, Klaus-Werner		x
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SYD - MMFU	
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