AWS DDB ICD

Arctic Weather Satellite

SYS

Doc. Reference:	AWS-OSE-ICD-0083	Project Abbreviation:	AWS
Issue:	05	Issue Date:	2024-03-22
State:	Released		
DRL Reference:	N/A	CI-number:	N/A

Action	Name	Function
Author:	Milan Battelino	System Engineer
Reviewed by:	Niklas Ahlgren	System engineer
Checked by:	Leonardo Ruo	PA
Authorised by:	Joakim Kugelberg	PM
Released by:	Ingrida Sriupsaite	DM

OHB Sweden AB
P.O. Box 1269
SE-164 29 KISTA
Sweden
Tel: +46 8 121 40 100
www.ohb-sweden.se

Distribution List

Name	No. of Copies	Company/Organisation
CADM		ESA
		Public

Document Change Record

Issue	Date	Section	Comments	Author
01.1	2022-02-17		Initial draft	Enrique Lamoureu x
01	2022-03-02		Issue for release	LHE
02.1	2022-06-03		New Revision	Milan Battelino
02.2	2022-06-03	5.2.3.1 6.1.2	Removed reference [RD4] Updated CCSDS Time Code Format fields in section 5.2.3.1 Specified endianness of CUC_TIME field in Science Packet	Milan Battelino
02.3	2022-06-03	6	All tables updated	Milan Battelino
02.4	2022-06-22	4.1.6	L-Band Data / symbol rate update to match TCM internal frequency dividers.	ELA
02.5	2022-11-23	Table 6-9	Interpretations added to manoeuvre flag, spacecraft mode & payload mode. SID specified	NAH
2.6	2023-01-24	Annex D	L-Band Link budget update	ELA
02	2023-01-28		Issue for release	LHE
03.1	2023-03-23	§5.2.3.1	Clarification on Time Preamble, Time epoch, and Time reference status	Vincent Garcia
03.2	2023-06-20	§5.2.2.1 §6.1.2	Removed TBC on APID numbers Updated Science packet format	Vincent Garcia
03	2023-06-27		Issue for release	LHE
04.1	2024-01-25	-	New revision	MBA
04.2	2024-01-25	§5.1 §5.2 §5.3	Editorial corrections. Clarification that trailer is not used in TM Transfer Frames over L-band.	MBA
04	2023-01-30		Issue for release	LHE

Issue	Date	Section	Comments	Author
5.1	2024-03-13	§4.1 Annex E	Downlink Physical layer update Antenna Radiation pattern based on measured values	ELA
05	2024-03-21		Issue for release	LHE

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 SCOPE

This document specifies the Direct Data Broadcast (DDB) service from the Arctic Weather Satellite.

The document describes:

- The downlink part of the Telecommunication System: frequencies, channel formats, polarisation, modulation, bit rates, coding
- The link budget and relevant figures of merit
- The telemetry structure: Telemetry Source Packet, Telemetry Transfer Frame, Channel Access Data Unit.

The document contains a number of annexes specifying:

- Conventions for bit numbering
- Virtual Channels
- Cyclic Redundancy Code (CRC)
- Parameter types and structure
- Time protocols and correlation
- Idle Packet structure

2. DOCUMENTS

2.1 APPLICABLE DOCUMENTS

This document shall be read in conjunction with documents listed hereafter, which form part of this document to the extent specified herein. In case of a conflict between any provisions of this document and the provisions of the documents listed hereafter, the content of the contractually higher document shall be considered as superseding.

AD	Doc. No.	Rev	Date	Title
[AD1]	CCSDS 401.0-B		Dec 2007	Radio frequency and modulation
[AD2]	CCSDS 131.0-B-2	2	Aug 2007	TM Synchronization and Channel coding
[AD3]	CCSDS 132.0-B-1	3	Sep 2003	TM Space Data Link Protocol
[AD4]	ECSS-E-ST-50-01C	C	July 2008	Space data links – Telemetry synchronization and channel coding
[AD5]	ECSS-E-70-41C	C	April 2016	Ground Systems and Operations – Telemetry and Telecommand Packet Utilisation
[AD6]	CCSDS-301.0-B-3	3	Jan 2002	Time Code Formats
[AD7]	CCSDS-355.0-B1	B1		Space Data Link Security Protocol

Table 2-1: Applicable Documents

2.2 REFERENCE DOCUMENTS

RD	Doc. No.	Rev	Date	Title
[RD1]	AWS-OSE-TN-0718	4		Satellite Technical Budgets external
[RD2]	IEEE 754:1985		1991	Standard for Binary Floating-Point Arithmetic
[RD3]	MIL-STD-1750a		July 1980	Military Standard Sixteen-Bit Computer Instruction Set Architecture
[RD4]	AWS-OMN-ICD-0003	7.0		Instrument software ICD
[RD5]	AWS-OSE-ICD-0063	6		Space To Ground ICD

Table 2-2: Reference Documents

2.3 ACRONYMS & ABBREVIATION LIST

The list below contains the general acronyms and abbreviations for this project.

Acronyms and Abbreviations	
APID	Application Process Identifier
ASM	Attached Synchronous Marker
AWS	Arctic Weather Satellite

Acronyms and Abbreviations	
CADU	Channel Access Data Unit
CDB	Configuration Database
DDB	Direct Data Broadcast
EIRP	Equivalent Isotropic Radiated Power
EOL	End of Life
GST	Ground Station
G/T	Station Gain over noise Temperature Ratio
HKTM	House-Keeping Telemetry
LTAN	Local Time of Ascending Node
LTDN	Local Time of Descending Node
MCS	Mission Control System
NAVATT	Navigation and Attitude packet
NWP	Numerical Weather Prediction
OBSW	Onboard Software
OBT	On-board Time
PDGS	Processing Data Ground System
RF	Radio Frequency
S/C	Spacecraft
SCDB	Spacecraft Characteristics DataBase
SCET	Spacecraft Elapsed Time
SMD	Stored Mission Data
SRDB	Spacecraft Reference DataBase
SSO	Sun Synchronous Orbit
ST	Star Tracker
TC	Telecommand
TLE	Two-line Element
TM	Telemetry
VCID	Virtual Channel Identifier

Table 2-3: Acronyms & Abbreviation List

2.4 DEFINITIONS

The list below contains the general definitions for this project.

Definitions	

Table 2-4: Acronyms & Abbreviation List

3. OVERVIEW OF THE AWS MISSION

3.1.1 AWS Mission description

The AWS PFM system is a precursor to a planned operational constellation of polar weather satellites. The AWS system comprises of a space segment (single satellite) and a ground segment.

The AWS satellite is based on the Innosat platform, a small, 3-axis stabilised spacecraft. The single payload is a microwave radiometer sensing water and humidity content over a wide swath using a rotating scanning mechanism. The instrument is constantly ON during the operational phase of the mission.

The AWS ground segment consists of one L-band ground station for Stored Mission Data, an S-band ground station for command and control, a satellite control centre and a processing centre of payload data.

Direct Data Broadcast is continuously transmitted in L-band for any meteorological user to access. Stored Mission Data is stored on-board and downloaded to the ground station at every L-band ground station contact to meet the data timeliness requirement. The L-band ground station is located in Svalbard, which grants frequent satellite access.

The satellite operates in two frequencies, S-band for HKTM and L-band for real time sensing data as well as for the downlink of Stored Mission Data. The S-band HKTM will be used in non-nominal situations when time critical operations are to be performed, such as on-board software maintenance and failure investigations.

The AWS mission is based on continuous payload operation, which implies that no management of user's requests are needed. All Level 0 and Level 1B processing is data-driven from what is collected at the Ground Station.

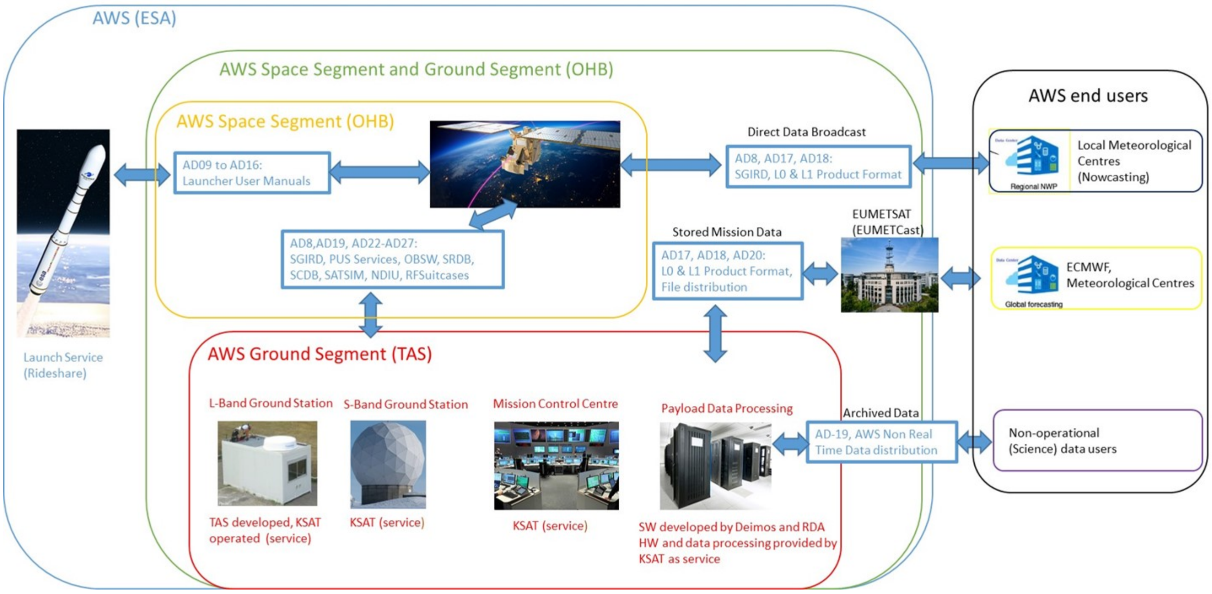


Figure 3-1 - AWS mission architecture

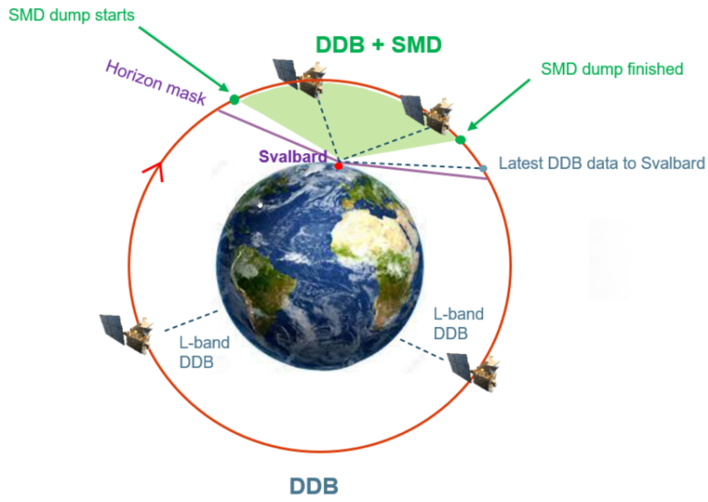
3.1.2 Space to ground communications

Each AWS satellite distributes continuously S/C science data stream (Instrument science packets + NAVATT) in L-band to support the regional Direct Data Broadcast (DDB) service.

Each AWS satellite collects and stores radiometric data over full orbits in a dedicated on-board mass memory partition. The Stored Mission Data (SMD) collected over each orbit is autonomously downloaded at every contact with the L-band Svalbard Ground station in the following pre-defined sequence:

- S/C events (platform and instruments), forwarded to MCS
- S/C Science stored data, forwarded to the PDGS
- S/C HK-TM stored data, forwarded to MCS

Each of these streams is then directly forwarded to MCS or PDGS based on VCID filtering.



4. L-BAND – PHYSICAL LAYER

The spacecraft telecommunication subsystem includes an L-band transmitter for the downlink of science data primarily.

The satellite telecommunication subsystem will be allocated with its dedicated frequency in the L-Band frequency range.

4.1 DOWNLINK

4.1.1 Frequencies

The downlink TM frequency band is 1.707GHz with a bandwidth of 3.4MHz [RD5].

4.1.2 Polarization

Right-hand circularization polarization (RHCP) is baselined in L-band.

4.1.3 Radiated power

The AWS satellite Equivalent Isotropically Radiated Power (EIRP) is defined in Annex D.

4.1.4 Telemetry channels formats

The telemetry format conforms to [AD2] and [AD3].

4.1.5 Modulation

For the downlink data, the downlink modulation scheme is QPSK.

4.1.6 Telemetry bit rates

The spacecraft telemetry data rate on the L-band link during science phase is:

- Total signal encoded rate: 3570kbps
- Symbol rate: 1785 kS/s

Total encoded rate includes packet headers, as well as CCSDS frame protocol headers, Reed Solomon overhead and convolutional encoding overhead. See 5.3.5 for further details.

4.1.7 Coding

The coding scheme for the telemetry is NRZ-L, following [AD4] & [AD2].

5. TELEMETRY STRUCTURE

5.1 INTRODUCTION

The protocol requirements for TM Source Packet and TM Transfer Frame are specified in this section.

TM Source Packet

The Source Packet is a data structure generated by an on-board Application Process. Aside from a packet header that identifies the source and characteristics of the packet, its internal data contents are completely under the control of the Application Process.

The requirements are specified in section 5.2.

Transfer Frame

The transfer frame is a data structure that provides an envelope for transmitting packetized data over a noisy space-to-ground channel.

The requirements are specified in section 5.3.

Channel Access Data Unit

The Channel Access Data Unit (CADU) is the data structure that comes out of the encoder and goes into the transmitter.

The requirements are specified in section 5.4

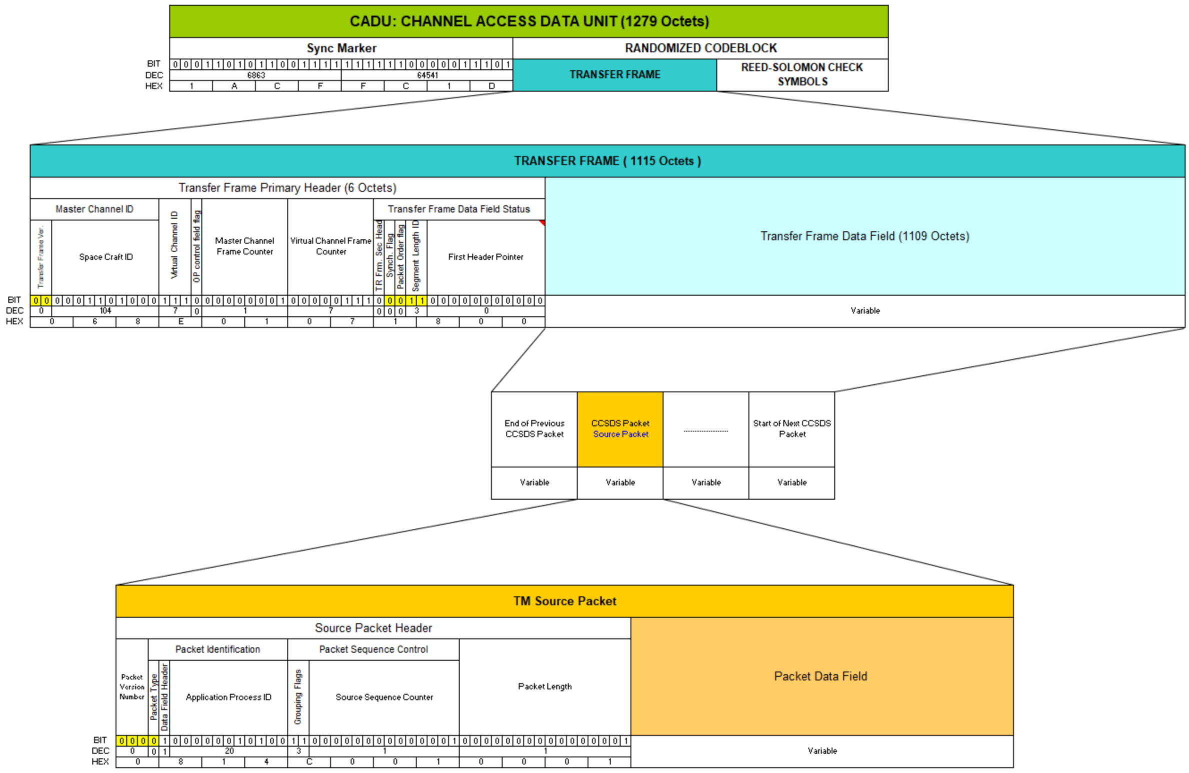


Figure 5-1 Telemetry structure example

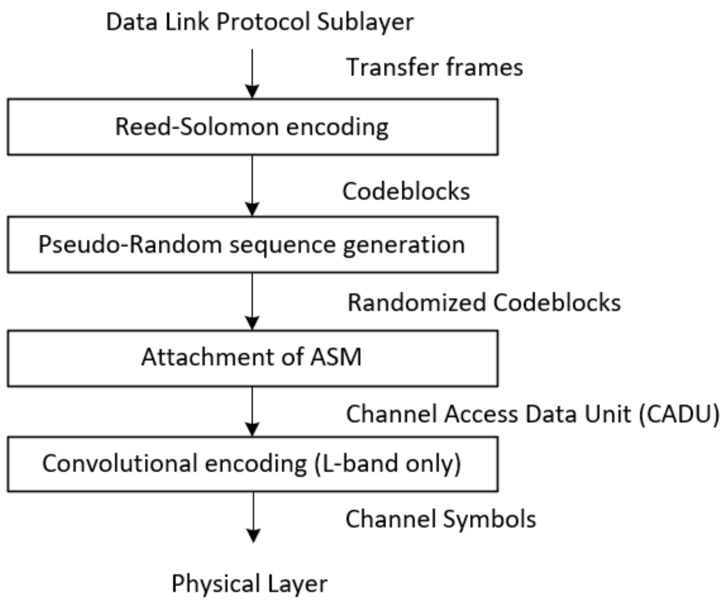


Figure 5-2 - AWS – Synchronization and Channel coding sublayer

5.2 TELEMETRY SOURCE PACKET

5.2.1 Source packet format

All Telemetry Source Packets must conform to the structure shown below.

SOURCE PACKET HEADER (48 bits)							PACKET DATA FIELD (VARIABLE)		
PACKET ID				PACKET SEQUENCE CONTROL		PACKET LENGTH	DATA FIELD HEADER (see below)	SOURCE DATA	PACKET ERROR CONTROL
Version Number	Type	Data Field Header Flag	Application Process ID	Grouping Flags	Source Sequence Count				
3	1	1	11	2	14				
16				16		16	Defined by CUC format	Variable	16

Data Field Header (64-120 Bits)								
TM Source Packet PUS Version Number (=2)	Spacecraft Time Reference Status	Service Type	Service Subtype	Message Type Counter (=0)	Destination ID	CCSDS Time Code Format		
						Preamble	CUC Time Seconds	CUC Time Fraction
4	4	8	8	16	16	8	(P-Field[4:5] + 1)*8	P-Field[6:7]*8

Figure 5-3: Telemetry source packet format

5.2.2 Source Packet Header

5.2.2.1 Packet ID

Version number	3 bits	Shall be set to ‘000’.
Type	1 bit	Shall be set to ‘0’ for TM packet.
Data Field Header Flag	1 bit	Shall be set to ‘1’ since a DFH will follow.
Application Process ID	11 bits	The Application Process ID corresponds uniquely to an on-board application which is the source of this packet. APID = 0 is reserved for the time packet APID = 11111111111 (11 ones) is reserved for idle packets. APID = 100 for the payload science data APID = 51 for the NAVATT data

5.2.2.2 Packet sequence control

Grouping flags	2 bits	00- Packet contains a continuation of User Data 01- Packet contains the first segment of User Data 10- Packet contains the last segment of User Data 11- Packet contains unsegmented user data Note: Segmented data is used on AWS
Source Sequence Count	14 bits	A separate source sequence count shall be maintained by each APID and shall be incremented by 1 whenever it releases a packet. Therefore the counter corresponds to the order of release of packets by the source and enables the destination (e.g. the ground system) to detect missing packets. This counter should never re-initialize; however, under no circumstances shall it “short-cycle” (i.e. have a discontinuity other than to a value zero). The counter wraps around from (2^{14} – 1) to zero.

5.2.2.3 Packet length

Packet Length	16 bits	The packet length field specifies the number of octets contained within the packet data field. The number shall be an unsigned integer ‘C’, where: C = (Number of octets in packet data field) - 1 Note: The actual length of the entire TM source packet, including the source packet header, is 7 octets longer. The maximum length of a TM source packet including packet header is 1024 octets for Innosat AWS Platform TM, and 16384 octets for Payload Science TM.

5.2.3 Packet Data Field

5.2.3.1 Data Field Header

TM Source Packet PUS Version Number	4 bits	Shall be set to ‘0010’.
Spacecraft Time Reference Status	4 bits	This field informs user of the status of the CUC time reference: 0000 = “Undefined” 0001 = “Not synchronized” 0010 = “Coarse”. Timekeeping after detection of at least one GNSS 0011 = “Coarse From Fine”. Timekeeping after transition from Spacecraft Time Reference Status “Fine”, i e with less than 4 GNSS. 0100 = “Fine”. Timekeeping with at least 4 GNSS
Service Type	8 bits	This indicates the Service to which this telemetry source packet relates.

<table>
<tr><td></td><td></td><td>Service types 0 to 127 are reserved for services specified in [AD2] (ECSS-E-70-41B); service types 128 to 255 are mission-specific.
NAVATT: 3
SCIENCE: 128</td></tr>
<tr><td>Service Sub-type</td><td>8 bits</td><td>Together with the service type, the subtype uniquely identifies the nature of the service report constituted by this telemetry source packet. Within standard services, subtypes 0 to 127 are reserved for [AD2] (ECSS-E-70-41B), subtypes 128 to 255 are mission-specific.
Within mission-specific services, all subtypes (0 to 255) are available for mission-specific use.
The definition of service type and subtype shall be unique across all application processes and the combination of these fields can be used on the ground to determine the processing priority level.
NAVATT: 25
SCIENCE: 25</td></tr>
<tr><td>Message Type Counter</td><td>16 bits</td><td>This field is not used by any onboard service. Shall be set to ‘0’.</td></tr>
<tr><td>Destination ID</td><td>16 bits</td><td>Two Destination Ids are considered for the application processes:
‘0’: Ground
‘1’: On-board</td></tr>
<tr><td>Preamble</td><td>8 bits</td><td>P-Field with value according to in [AD1] (CCSDS 301.0-B-3):
<table>
<tr><td>Bit 0</td><td>Extension Flag</td><td>Value = 0 (No extension)</td></tr>
<tr><td>Bit 1-3</td><td>Time Code Id</td><td>Value = 1 or 2</td></tr>
<tr><td>Bit 4-5</td><td>Coarse Time</td><td>Value = number octets - 1</td></tr>
<tr><td>Bit 6-7</td><td>Fine Time</td><td>Value = number octets</td></tr>
</table>
Preamble Value for AWS are:
• 00101111b = 2Fh = 47d
which implies:
• Extension Flag = 0
• Time Code Id = 2
• Coarse Time = 3
• Fine Time = 3</td></tr>
</table>

CUC Time Seconds	4*8 bits	The on-board coarse reference time of the packet CUC format (seconds), as defined in [AD1] (CCSDS 301.0-B-3). The packet on-board time corresponds to any well-defined time before the sampling of any data within the packet. For AWS 4 * 8 bits are used, containing seconds since GPS Epoch 1980-01-06 00:00:00 with no leap seconds.
CUC Time Fraction	3*8 bits	The on-board fine reference time of the packet CUC format (fraction), as defined in [AD1] (CCSDS 301.0-B-3). The packet on-board time corresponds to any well-defined time before the sampling of any data within the packet. For AWS 3 * 8 bits are used, containing the fraction of the second in CUC Time Seconds field.

5.2.3.2 Source Data

The packet source data constitute the data element of the telemetry reports to the ground.

Details on the structure of the TM source data is specified in §6.

Compression is not used for platform or payload telemetry.

5.2.3.3 Spare

In order to make sure that the overall packet size is an integral number of words, spare bits may be used for padding purposes at the end of the source data. The word size is for all application processes is one octet. Padding to achieve packets with integral number of words is mandatory in PUS issue 2, see 7.4.3.2c [AD3].

5.2.3.4 Packet error control

The packet error control field transports an error detection code that can be used by the ground system to verify the integrity of the complete telemetry source packet. The presence of the PEC and its type is fixed for the complete mission.

Packet error control	16 bits	CRC-16-CCITT, calculated over the complete TM Source Packet (excluding the PEC itself), see B.1 [AD3].

5.3 TELEMETRY TRANSFER FRAME

All Telemetry Transfer Frames must conform to the format shown in Figure 5-4.

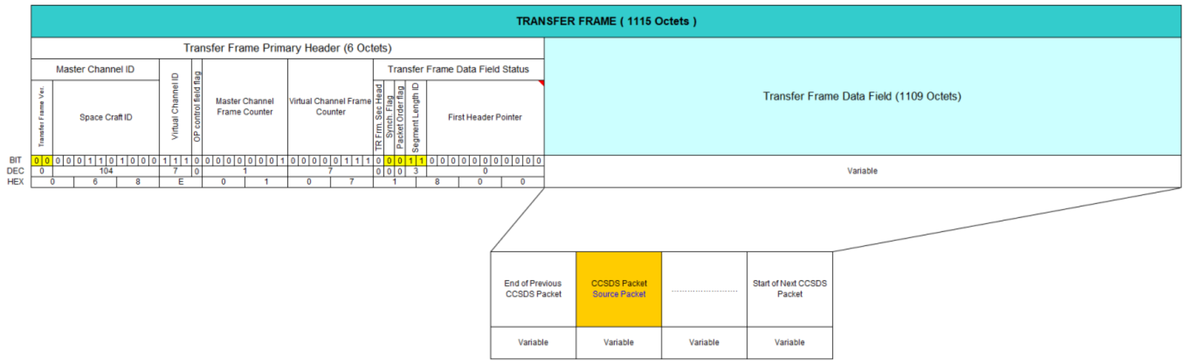


Figure 5-4: Telemetry Transfer Frame format example

5.3.1 Transfer frame length

A standard Transfer Frame Length of 1115 octets shall be used. This length corresponds to a standard Reed-Solomon code block structure, with an interleaving depth of five, and it shall result in a total R-S code block length of 1275 octets. After ASM insertion, the complete CADU length is 1279 octets.

5.3.2 Transfer frame primary header

5.3.2.1 Transfer frame identification

Version Number	Shall be set to ‘00’.
S/C Identification	Refer to section Annex G
Virtual Channel Identification	This 3-bit field enables up to eight Virtual Channels to be run on a particular physical data channel. Refer to section B.1.
Operational Control Field Flag	This 1-bit field indicates the presence (value = ‘1’) or absence (value = ‘0’) of the Operational Control Field within the Transfer Frame Trailer. The Operational Control Field Flag shall be set to 0 for L-band data, indicating no OCF and therefore no Transfer Frame Trailer.

5.3.2.2 Master channel frame count

The Master Channel Frame Count provides an 8-bit sequential up-count of each Transfer Frame generated by the platform on the Master Channel. The counter must be left free running, i.e. it shall never be short-cycled. When the counter is “full”, it shall be reset to ‘0’.

5.3.2.3 Virtual channel frame count

The Virtual Channel Frame Count is used in association with the Virtual Channel Identifier. It provides a separate 8-bit up-counter for each of the Virtual Channels. These counters must be free running, i.e. they shall never be short-cycled. When the counter is “full”, it shall be reset to ‘0’.

5.3.2.4 Frame data field status

Secondary Header Flag	This flag indicates the presence (value = ‘1’) or absence (value = ’0’) of the Transfer Frame Secondary Header. No Secondary Header shall be used (see section 5.3.3), and the flag shall therefore be set to ‘0’.
Synchronisation Flag	This flag indicates whether or not the packet data units are inserted into the Transfer Frame data field on octet boundaries. If they are, then they are said to be “synchronously inserted” (packet octet boundaries align with frame octet boundaries) and the standard extraction technique is valid (value = ’0’). If the flag indicates “asynchronous” data insertion (value = ‘1’), it means that unstructured (non-packetized) data contents or packets are inserted, without regard to octet boundaries. The receiving end will not be able to reconstitute the original data sets without additional knowledge and shall ignore the remaining frame data. All telemetry data on Innosat AWS shall be packetized and the flag shall therefore be set to ‘0’.
Packet Order Flag	During real-time transmission of data from spacecraft sources to the ground, the order of the Telemetry Packets inserted within the Transfer Frames will be defined as ‘forward justified’. This means that they will appear with the most significant bit transmitted first, and with their sequence counters increasing. The TT&C Control Module of the S/C platform contains an FLASH mass memory module, which can be read out in forward order. In the Packet Telemetry Standard only the forward order of synchronous insertion of packets is recognised. Therefore, the flag shall always be set to ‘0’.
Segment Length Identifier	The Segment Length Identifier shall be set to ‘11’,
First Header Pointer	The First Header Pointer sub-field points directly to the location of the starting octet of the first packet header structure within the frame data field. It counts from the end of the primary header and effectively delimits the beginning of the first packet. The packet length field, in turn, delimits the beginning of the next packet, and so on. Since the pointer counts octets, this feature works only when the headers are aligned with octet boundaries, i.e., when the packet data are synchronously inserted (data field synchronization flag set to ‘0’). The eleven bits allocated to the pointer allow for a count to 2048 octets, which exceeds the count required to point to an octet at the end of the data field. Special pointer values are used to denote: • No packet/segment header is contained in this frame, but there is valid data; “11111111111”. or • No valid data is contained in this frame (“idle channel”). “11111111110’.

	Note: This feature is used to detect instrument science packets spread out over multiple transfer frames

5.3.3 Transfer frame secondary header

A Secondary Header shall not be used.

5.3.4 Transfer frame data field

The Transfer Frame data field contains an integral number of octets of data (e.g., Source Packets) to be transmitted from the spacecraft to the ground. The length of this field is 1109 octets (1115 – 6) for L-band.

5.3.5 Channel encoding and pseudo-randomization

<u>L-band</u>

The encoding scheme for the telemetry at frame level is

- Reed-Solomon (255,223) with an interleaving depth of 5 as outer code
- Convolutional encoding (7,1/2) for the inner code

In accordance with the definition in [AD4] & [AD2]. Pseudo-randomization is applied after RS encoding to guarantee sufficient bit transition to ensure bit synchronisation.

5.4 CHANNEL ACCESS DATA UNIT

The Channel Access Data Unit format shall conform to the requirements of [AD4].

For AWS, the ASM synchronization marker in L-band is: **1ACFFC1D**.

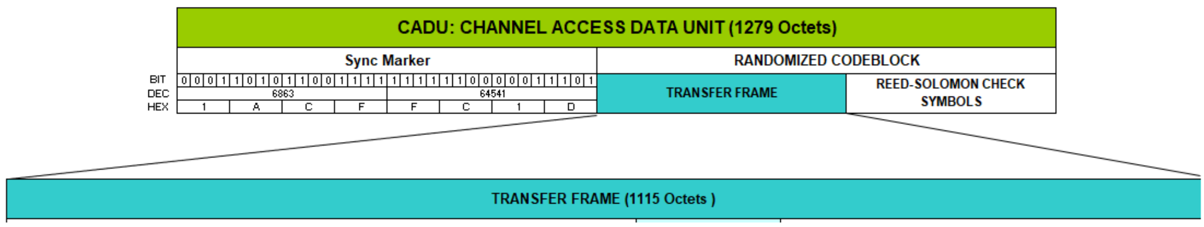


Figure 5-5 CADU structure

6. S/C SCIENCE TELEMETRY DATA

6.1 INSTRUMENT DATA

The radiometer will measure absolute power on the 54, 89, 166/183 and 325 GHz bands, subdivided into 19 sub-bands (or channels), expressed in Kelvin (K).

Channel	Receiver	RF center frequency [MHz]	IF Center frequency [MHz]	Bandwidth [MHz]
AWS-11	54GHz	50.3	2300	180
AWS-12	54GHz	52.8	4800	400
AWS-13	54GHz	53.246	5246	300
AWS-14	54GHz	53.596	5596	370
AWS-15	54GHz	54.4	6400	400
AWS-16	54GHz	54.94	6940	400
AWS-17	54GHz	55.5	7500	330
AWS-18	54GHz	57.290344	9290.344	330
AWS-21	89GHz	89	No IF	4000
AWS-31	183GHz	165.5	2924	2800
AWS-32	183GHz	176.311	13735	2000
AWS-33	183GHz	178.811	16235	2000
AWS-34	183GHz	180.311	17735	1000
AWS-35	183GHz	181.511	18935	1000
AWS-36	183GHz	182.311	19735	500
AWS-41	325GHz	325.15 ± 1.20	1200	800
AWS-42	325GHz	325.15 ± 2.40	2400	1200
AWS-43	325GHz	325.15 ± 4.10	4100	1800
AWS-44	325GHz	325.15 ± 6.60	6600	2800

Table 6-1 AWS frequency band plan

6.1.1 Auxiliary data

Variable	Unit	Description
plcOpticsAzimuth	Degrees	Per-receiver Azimuth angle
plcOpticsElevation	Degrees	Per-receiver Elevation angle
plcEncoderOffset	Degrees	Mirror offset angle
plcWeightsObct	Unitless	OBCT calibration coefficients
plcWeightsCold	Unitless	COLD calibration coefficients
plcTempObctAdc	Volt	OBCT PT1000 adc value to resistance
plcTempObctRes2Temp	Kelvin/Volt	Resistance to Temperature coefficients
plcTempObctLimit	Kelvin	Out-of-range upper/lower
plcTempPsuVadc	Volt	ADC reference voltage
plcTempPsuVref	Volt	NTC circuit reference voltage
plcTempPsuR1	Ohm	NTC circuit R1 resistor value
plcTempPsuR2	Ohm	NTC circuit R2 resistor value
plcTempPsuR3	Ohm	NTC circuit R3 resistor value
plcTempPsuBeta	Kelvin/Ohm	NTC sensor beta value
plcTempPsuR25	Ohm	NTC sensor nominal resistance
plcTempPsuLimit	Kelvin	Sensor out-of-range upper/lower
plcTempIcuVadc	Volt	ADC reference voltage
plcTempIcuVref	Volt	NTC circuit reference voltage
plcTempIcuR1	Ohm	NTC circuit R1 resistor value
plcTempIcuR2	Ohm	NTC circuit R2 resistor value
plcTempIcuR3	Ohm	NTC circuit R3 resistor value
plcTempIcuBeta	Kelvin/Ohm	NTC sensor beta value
plcTempIcuR25	Ohm	NTC sensor nominal resistance
plcTempIcuLimit	Kelvin	Sensor out-of-range upper/lower
plcTempAuxVadc	Volt	ADC reference voltage
plcTempAuxVref	Volt	NTC circuit reference voltage
plcTempAuxR1	Ohm	NTC circuit R1 resistor value
plcTempAuxR2	Ohm	NTC circuit R2 resistor value
plcTempAuxR3	Ohm	NTC circuit R3 resistor value
plcTempAuxBeta	Kelvin/Ohm	NTC sensor beta value
plcTempAuxR25	Ohm	NTC sensor nominal resistance
plcTempAuxLimit	Kelvin	Sensor out-of-range upper/lower
plcTempHeaterVadc	Volt	ADC reference voltage
plcTempHeaterVref	Volt	NTC circuit reference voltage
plcTempHeaterR1	Ohm	NTC circuit R1 resistor value
plcTempHeaterR2	Ohm	NTC circuit R2 resistor value
plcTempHeaterR3	Ohm	NTC circuit R3 resistor value
plcTempHeaterBeta	Kelvin/Ohm	NTC sensor beta value
plcTempHeaterR25	Ohm	NTC sensor nominal resistance
plcTempHeaterLimit	Kelvin	Sensor out-of-range upper/lower
plcVoltageReceiverAdc	Volt	ADC value to voltage
plcVoltageReceiverLimit	Volt	Out-of-range upper/lower
plcCurrentReceiverAdc	Amp	ADC value to current
plcCurrentReceiverLimit	Amp	Out-of-range upper/lower
plcTempReceiverBeVadc	Volt	ADC reference voltage
plcTempReceiverBeVref	Volt	NTC circuit reference voltage
plcTempReceiverBeR1	Ohm	NTC circuit R1 resistor value
plcTempReceiverBeR2	Ohm	NTC circuit R2 resistor value
plcTempReceiverBeR3	Ohm	NTC circuit R3 resistor value
plcTempReceiverBeBeta	Kelvin/Ohm	NTC sensor beta value
plcTempReceiverBeR25	Ohm	NTC sensor nominal resistance
plcTempReceiverBeLimit	Kelvin	Sensor out-of-range upper/lower
plcTempReceiverFeVadc	Volt	ADC reference voltage
plcTempReceiverFeVref	Volt	NTC circuit reference voltage

Table 6-2 Auxiliary data inputs 1(2)

plcTempReceiverFeR1	Ohm	NTC circuit R1 resistor value
plcTempReceiverFeR2	Ohm	NTC circuit R2 resistor value
plcTempReceiverFeR3	Ohm	NTC circuit R3 resistor value
plcTempReceiverFeBeta	Kelvin/Ohm	NTC sensor beta value
plcTempReceiverFeR25	Ohm	NTC sensor nominal resistance
plcTempReceiverFeLimit	Kelvin	Sensor out-of-range upper/lower
plcTempReceiverLoVadc	Volt	ADC reference voltage
plcTempReceiverLoVref	Volt	NTC circuit reference voltage
plcTempReceiverLoR1	Ohm	NTC circuit R1 resistor value
plcTempReceiverLoR2	Ohm	NTC circuit R2 resistor value
plcTempReceiverLoR3	Ohm	NTC circuit R3 resistor value
plcTempReceiverLoBeta	Kelvin/Ohm	NTC sensor beta value
plcTempReceiverLoR25	Ohm	NTC sensor nominal resistance
plcTempReceiverLoLimit	Kelvin	Sensor out-of-range upper/lower
plcCurrentMotorAdc	Amp	ADC value to current
plcCurrentMotorLimit	Amp	Out-of-range upper/lower
plcTempMotorVadc	Volt	ADC reference voltage
plcTempMotorVref	Volt	NTC circuit reference voltage
plcTempMotorR1	Ohm	NTC circuit R1 resistor value
plcTempMotorR2	Ohm	NTC circuit R2 resistor value
plcTempMotorR3	Ohm	NTC circuit R3 resistor value
plcTempMotorBeta	Kelvin/Ohm	NTC sensor beta value
plcTempMotorR25	Ohm	NTC sensor nominal resistance
plcTempMotorLimit	Kelvin	Sensor out-of-range upper/lower
plcRfAdc2mW	mW	ADC value to milliwatts
plcRfOffsetObct	Kelvin	Effective OBCT temperature offset
plcRfOffsetCold	Kelvin	Effective COLD temperature offset
plcRfLimit	TBD	Out-of-range upper/lower

Table 6-3 Auxiliary data inputs 2(2)

6.1.2 Science packets data

6.1.2.1 Science packet structure

Each instrument data packet contains FOV scene observation, hot/cold calibration load measurement and instrument house-keeping telemetry (static and dynamic) related to a full revolution of the scanning mechanism which operates at ~0.9Hz. The raw data packets are **Little-Endian** byte order, with the exception of the CUC_TIME field which are in **Big-Endian** byte order.

Name	Description	Range	Type	Size (bytes)	Offset (bytes)
HK_STATIC	Static Housekeeping, see section 6.4		-	70	0
HK_DYNAMIC	Dynamic Housekeeping, see section 6.5		-	104	70
PLSTATUS	Payload Status FDIR flags, see section 6.2		-	17	174
CUC_TIME	CUC timestamp Latched when Scene measurement start Preamble 8 bits Seconds 32bits Fractional seconds 24 bits		cuc	8	191
SPOT[0]	OBCT Spot 1		-	40	199
…			-		…
SPOT[i-1]	OBCT Spot i			40	749
SPOT[i]	COLD Spot 1		-	40	799
…			-		…
SPOT[i+j-1]	COLD Spot j		-	40	1751
SPOT[i+j]	SCENE Spot 1			40	1799
…					…
SPOT[i+j+k-1]	SCENE Spot k			40	7559
			Total size:	**7599**	

Table 6-4 AWS Science Data packet structure. Note that the references to sections in the "Description" column are not applicable for this document. In this document "section 6.4" is referring to section 6.1.2.2, "section 6.5" to section 6.1.2.4 and "section 6.2" to section 6.1.2.5

The table above illustrates the instrument payload data for one revolution of the instrument mirror. The data has 19 columns (one for each RF band) and i, j, k rows respectively (i hot reference load measurement, j cold target view measurements and k FOV scene observations).

The motor encoder telemetry shall be used to derive the instrument CUC_TIME of each spot measurement considering the mechanism rotating frequency and number of spots senser (i+j+k+2).

6.1.2.2 HK_STATIC structure

Name	Description	Range	Type	Size (bytes)	Offset (bytes)
PLID	Payload ID, unique for each payload instrument		uint16	2	0
SWPART	Software Part ID		uint16	2	2
SWREV	Software Revision		uint8	1	4
SWTAGX	Software SVN TAG X number		uint8	1	5
SWTAGY	Software SVN TAG Y number		uint8	1	6
SWTAGZ	Software SVN TAG Z number		uint8	1	7
FWPART	FPGA firmware Part ID		uint16	2	8
FWREV	FPGA firmware Revision		uint8	1	10
FWTAGX	FPGA firmware SVN TAG X number		uint8	1	11
FWTAGY	FPGA firmware SVN TAG Y number		uint8	1	12
FWTAGZ	FPGA firmware SVN TAG Z number		uint8	1	13
CONFFILE	Configuration File, see Table 7		-	56	14
			Total size:	**70**	

Table 6-5 Static Instrument Housekeeping parameters (HK_STATIC). Note that the reference to "Table 7" in the "Description" column is not applicable for this document. In this document "Table 7" is referring to section 6.1.2.3

6.1.2.3 HK_STATIC Configuration file structure

Name	Description	Range	Type	Size (bytes)	Offset (bytes)
SYS_SCRUBBER	System memory scrubber enable/disable Disabled Enabled, at specified interval in seconds	 0 >=1	uint8	1	0
FDIR_EN	FDIR enable/disable. Same format as PLSTATUS data.		uint8	17	1
OBCT_START	OBCT view encoder start position		uint16	2	18
OBCT_SPOTS	OBCT view number of spots	i	uint16	2	20
COLD_START	Cold view encoder start position		uint16	2	22
COLD_SPOTS	Cold view number of spots	j	uint16	2	24
SCENE_START	Scene view encoder start position		uint16	2	26
SCENE_SPOTS	Scene view number of spots	k	uint16	2	28
SPEED	Motor speed setting		uint8	1	30
ACC_SPOTS	Accumulation for each spot	1, 2, 4, 8, 16	uint8	1	31
INDEX_POS	Mirror index position (zero)		uint16	2	32
CONV_WAIT	Receiver ADC conversion wait		uint16	2	34
REC_ENABLE	Receiver enable/disable	0..15	uint8	1	36
REC54_LO_POWER	54 GHz receiver LO power	0..63	uint8	1	37
REC183_LO_POWER	183 GHz receiver LO power	0..63	uint8	1	38
REC325_LO_POWER	325 GHz receiver LO power	0..63	uint8	1	39
HEAT_SETP1_MAX	Heater 1 maximum setpoint.		uint16	2	40
HEAT_SETP1_MIN	Heater 1 minimum setpoint.		uint16	2	42
HEAT_SETP2_MAX	Heater 2 maximum setpoint.		uint16	2	44
HEAT_SETP2_MIN	Heater 2 minimum setpoint.		uint16	2	46
HEAT_SETP3_MAX	Heater 3 maximum setpoint.		uint16	2	48
HEAT_SETP3_MIN	Heater 3 minimum setpoint.		uint16	2	50
HEAT_SETP4_MAX	Heater 4 maximum setpoint.		uint16	2	52
HEAT_SETP4_MIN	Heater 4 minimum setpoint.		uint16	2	54
			Total size:	**56**	

Table 6-6 HK_STATIC Configuration File

6.1.2.4 HK_Dynamic structure

Name	Description	Range	Type	Size (bytes)	Offset (bytes)
PSU_TEMP1	PSU temperature sensor 1		uint16	2	0
PSU_TEMP2	PSU temperature sensor 2		uint16	2	2
ICU_TIME	ICU real time counter, CUC format Preamble 8 bits, Seconds 32bits Fractional seconds 24 bits		uint64	8	4
ICU_EDAC	EDAC status, Number of corrected 1-bit errors		uint16	2	12
ICU_SCRUB	Number of passes though ESRAM memory for scrubber.		uint16	2	14
ICU_VOLT	ICU +12V rail voltage		uint16	2	16
ICU_CURR	ICU +12V rail current		uint16	2	18
ICU_TEMP1	ICU temperature sensor 1		uint16	2	20
ICU_TEMP2	ICU temperature sensor 2		uint16	2	22
AUX_TEMP1	Auxiliary NTC temperature sensor 1		uint16	2	24
AUX_TEMP2	Auxiliary NTC temperature sensor 2		uint16	2	26
AUX_TEMP3	Auxiliary NTC temperature sensor 3		uint16	2	28
AUX_TEMP4	Auxiliary NTC temperature sensor 4		uint16	2	30
AUX_TEMP5	Auxiliary NTC temperature sensor 5		uint16	2	32
AUX_TEMP6	Auxiliary NTC temperature sensor 6		uint16	2	34
MOTOR_TEMP	Motor temperature sensor		uint16	2	36
MOTOR_CURR	Motor current sensor		uint16	2	38
MOTOR_AUX	Motor auxiliary sensor		uint16	2	40
MOTOR_SPEED	Motor speed		uint16	2	42
OBCT_TEMP1	Calibration load temperature sensor 1		uint16	2	44
OBCT_TEMP2	Calibration load temperature sensor 2		uint16	2	46
OBCT_TEMP3	Calibration load temperature sensor 3		uint16	2	48
OBCT_TEMP4	Calibration load temperature sensor 4		uint16	2	50
HEAT_STAT	Heater status. Enabled/On if bit is '1', Disabled/Off if bit is '0'. Bit [7] – Heater 4 On/Off Bit [6] – Heater 3 On/Off Bit [5] – Heater 2 On/Off Bit [4] – Heater 1 On/Off Bit [3] – Heater 4 Enable/Disable Bit [2] – Heater 3 Enable/Disable Bit [1] – Heater 2 Enable/Disable Bit [0] – Heater 1 Enable/Disable		uint8	1	52
HEAT_TEMP1	Heater temperature sensor 1		uint16	2	53
HEAT_TEMP2	Heater temperature sensor 2		uint16	2	55
HEAT_TEMP3	Heater temperature sensor 3		uint16	2	57
HEAT_TEMP4	Heater temperature sensor 4		uint16	2	59
REC_STAT	Bit [7..4] – '0' Bit [3] – LCL325 Bit [2] – LCL183 Bit [1] – LCL89 Bit [0] – LCL54		uint8	1	61
REC_PACKET_CNTR	Receiver packet counter		uint16	2	62

Table 6-7 Dynamic Instrument Housekeeping parameters 1(2) (HK_DYNAMIC)

Name	Description	Range	Type	Size (bytes)	Offset (bytes)
REC54_VOLT	54 GHz Receiver voltage		uint16	2	64
REC54_CURR	54 GHz Receiver current		uint16	2	66
REC54_TEMP_LO	Temperature sense LO		uint16	2	68
REC54_TEMP_PWRIO	Temperature sense FE Bias		uint16	2	70
REC54_TEMP_FEBIAS	Temperature sense BE		uint16	2	72
REC89_VOLT	89 GHz Receiver voltage		uint16	2	74
REC89_CURR	89 GHz Receiver current		uint16	2	76
REC89_TEMP_LO	Temperature sense LO		uint16	2	78
REC89_TEMP_PWRIO	Temperature sense FE Bias		uint16	2	80
REC89_TEMP_FEBIAS	Temperature sense BE		uint16	2	82
REC183_VOLT	183 GHz Receiver voltage		uint16	2	84
REC183_CURR	183 GHz Receiver current		uint16	2	86
REC183_TEMP_LO	Temperature sense LO		uint16	2	88
REC183_TEMP_PWRIO	Temperature sense FE Bias		uint16	2	90
REC183_TEMP_FEBIAS	Temperature sense BE		uint16	2	92
REC325_VOLT	325 GHz Receiver voltage		uint16	2	94
REC325_CURR	325 GHz Receiver current		uint16	2	96
REC325_TEMP_LO	Temperature sense LO		uint16	2	98
REC325_TEMP_PWRIO	Temperature sense FE Bias		uint16	2	100
REC325_TEMP_FEBIAS	Temperature sense BE		uint16	2	102
			Total size:	104	

Table 6-8 Dynamic Instrument Housekeeping parameters 2(2) (HK_DYNAMIC)

6.1.2.5 Payload Status structure

Name	Description	Range	Type	Size (bytes)	Offset (bytes)
STAT MAIN	**Bit [7] – LCL325** **Bit [6] – LCL183** **Bit [5] – LCL89** **Bit [4] – LCL54** **Bit [3] – SLOT** Nominal ICU Redundant ICU **Bit [2..0] – MODE** Bootloader Mode Startup Mode Operation Mode Safe Mode Test Mode	 '0' '1' 1 2 3 4 5	uint8	1	0
FAULT MAJOR SYSTEM	**Bit [7..1] – '0'** **Bit [0] – BOOT** BOOT bit is always set on boot and should be cleared manually to detect any unexpected reboots.		uint8	1	1

Name	Description	Range	Type	Size (bytes)	Offset (bytes)
FAULT MAJOR PCU	Bit [7..6] – ‘0’ Bit [5] – VOLT_ICU Bit [4] – CURR_ICU Bit [3] – TEMP_PSU2 Bit [2] – TEMP_PSU1 Bit [1] – TEMP_ICU2 Bit [0] – TEMP_ICU1		uint8	1	2
FAULT MAJOR MOTOR	Bit [7..6] – ‘0’ Bit [5] – CURR_CMD Bit [4] – CURR_MEAS Bit [3] – TEMP Bit [2] – ENC_ERR Bit [1] – ENC_HS Bit [0] – ENC_UNRESP		uint8	1	3
FAULT MINOR REC54	Bit [7] – LD Bit [6] – LCL Bit [5] – SPI Bit [4] – VOLT Bit [3] – CURR Bit [2] – TEMP_LO Bit [1] – TEMP_PWRIO Bit [0] – TEMP_FEBIAS		uint8	1	4
FAULT MINOR REC89	Bit [7] – LD Bit [6] – LCL Bit [5] – SPI Bit [4] – VOLT Bit [3] – CURR Bit [2] – TEMP_LO Bit [1] – TEMP_PWRIO Bit [0] – TEMP_FEBIAS		uint8	1	5
FAULT MINOR REC183	Bit [7] – LD Bit [6] – LCL Bit [5] – SPI Bit [4] – VOLT Bit [3] – CURR Bit [2] – TEMP_LO Bit [1] – TEMP_PWRIO Bit [0] – TEMP_FEBIAS		uint8	1	6
FAULT MINOR REC325	Bit [7] – LD Bit [6] – LCL Bit [5] – SPI Bit [4] – VOLT Bit [3] – CURR Bit [2] – TEMP_LO Bit [1] – TEMP_PWRIO Bit [0] – TEMP_FEBIAS		uint8	1	7
WARNING PCU	Bit [7] – PPS Bit [6] – ‘0’ Bit [5] – VOLT_ICU Bit [4] – CURR_ICU Bit [3] – TEMP_PSU2 Bit [2] – TEMP_PSU1 Bit [1] – TEMP_ICU2 Bit [0] – TEMP_ICU1		uint8	1	8

Name	Description	Range	Type	Size (bytes)	Offset (bytes)
WARNING MOTOR	Bit [7..5] – '0' Bit [4] – CURR_MEAS Bit [3] – TEMP Bit [2..0] – '0'		uint8	1	9
WARNING REC54	Bit [7..5] – '0' Bit [4] – VOLT Bit [3] – CURR Bit [2] – TEMP_LO Bit [1] – TEMP_PWRIO Bit [0] – TEMP_FEBIAS		uint8	1	10
WARNING REC89	Bit [7..5] – '0' Bit [4] – VOLT Bit [3] – CURR Bit [2] – TEMP_LO Bit [1] – TEMP_PWRIO Bit [0] – TEMP_FEBIAS		uint8	1	11
WARNING REC183	Bit [7..5] – '0' Bit [4] – VOLT Bit [3] – CURR Bit [2] – TEMP_LO Bit [1] – TEMP_PWRIO Bit [0] – TEMP_FEBIAS		uint8	1	12
WARNING REC325	Bit [7..5] – '0' Bit [4] – VOLT Bit [3] – CURR Bit [2] – TEMP_LO Bit [1] – TEMP_PWRIO Bit [0] – TEMP_FEBIAS		uint8	1	13
WARNING HEAT	Bit [7..4] – '0' Bit [3] – TEMP4 Bit [2] – TEMP3 Bit [1] – TEMP2 Bit [0] – TEMP1		uint8	1	14
WARNING AUX	Bit [7..6] – '0' Bit [5] – TEMP6 Bit [4] – TEMP5 Bit [3] – TEMP4 Bit [2] – TEMP3 Bit [1] – TEMP2 Bit [0] – TEMP1		uint8	1	15
WARNING OBCT	Bit [7..4] – '0' Bit [3] – TEMP4 Bit [2] – TEMP3 Bit [1] – TEMP2 Bit [0] – TEMP1		uint8	1	16
			Total size:	17	

Figure 6-1 Payload_status parameters

6.1.2.6 CUC_Time structure

The structure of the CUC_TIME field and value of the preamble is specified in section 5.2.3.1.

6.1.2.7 SPOT structure

Name	Description	Range	Type uint16	Size (bytes)	Offset (bytes)
AWS-11	54 GHz receiver Data, channel 1		uint16	2	0
AWS-12	54 GHz receiver Data, channel 2		uint16	2	2
AWS-13	54 GHz receiver Data, channel 3		uint16	2	4
AWS-14	54 GHz receiver Data, channel 4		uint16	2	6
AWS-15	54 GHz receiver Data, channel 5		uint16	2	8
AWS-16	54 GHz receiver Data, channel 6		uint16	2	10
AWS-17	54 GHz receiver Data, channel 7		uint16	2	12
AWS-18	54 GHz receiver Data, channel 8		uint16	2	14
AWS-21	89 GHz receiver Data, channel 1		uint16	2	16
AWS-31	183 GHz receiver Data, channel 1		uint16	2	18
AWS-32	183 GHz receiver Data, channel 2		uint16	2	20
AWS-33	183 GHz receiver Data, channel 3		uint16	2	22
AWS-34	183 GHz receiver Data, channel 4		uint16	2	24
AWS-35	183 GHz receiver Data, channel 5		uint16	2	26
AWS-36	183 GHz receiver Data, channel 6		uint16	2	28
AWS-41	325 GHz receiver Data, channel 1		uint16	2	30
AWS-42	325 GHz receiver Data, channel 2		uint16	2	32
AWS-43	325 GHz receiver Data, channel 3		uint16	2	34
AWS-44	325 GHz receiver Data, channel 4		uint16	2	36
ENC	Encoder, contingency channel		uint16	2	38
			Total size:	**40**	

Figure 6-2 SPOT parameters

6.2 NAVATT DATA

The following Navigation and Attitude data – referred as NAVATT – is generated on-board at 1Hz and included in the same data stream as the Instrument Science data packets. It contains the necessary information to perform the instrument data ground processing. The data packets are in **Big-Endian** byte order.

Name	Unit	Type	Size (Bytes)	Offset	Description
Headers			**21**	**0**	Source packet header + Data field header
SID	N/A	uint16	2	21	= 1
Navigation timestamp	Seconds	float64	8	23	AOCS slow core execution time
Orbit number	N/A	uint24	3	31	Per PUS 22
Orbit Fraction	N/A	uint32	4	34	Based on the angle measured in the plane of the osculating inertial orbit starting from the intersection with the Earth Fixed Equatorial Plane in ascending direction The Orbit Angle [deg] = 360 * Orbit Fraction / 232, LSB corresponds to an angle of 8.3819e-08deg
PosVel Quality	N/A	uint8	1	38	0 - None (worst) 1 - TLE 2 - Propagation 3 - GNSS (best)
X position	Meter	float32	4	39	Position (J2000)
Y position	Meter	float32	4	43	Position (J2000)
Z position	Meter	float32	4	47	Position (J2000)
X Velocity	Meter/Second	float32	4	51	Velocity (J2000)
Y Velocity	Meter/Second	float32	4	55	Velocity (J2000)
Z Velocity	Meter/Second	float32	4	59	Velocity (J2000)
Attitude timestamp	Seconds	float64	8	63	AOCS Fast Core (selected) Execution Time
Attitude Quality	N/A	uint8	1	71	0 - None (worst) 1 - Torque only 2 - GYR only 3 - ST1 only 4 - ST2 only 5 - ST1 & ST2 6 - ST1 & GYR only 7 - ST2 & GYR only 8 - ST1 & ST2 & GYR (best)
Quaternion	N/A	float64	4x8	72	Quaternions represent the transformation between ECI frame and Spacecraft Body (SCB) frame
X Rate	Rad/second	float32	4	104	Spacecraft body angular X rate (in spacecraft body frame)

Y Rate	Rad/second	float32	4	108	Spacecraft body angular Y rate (in spacecraft body frame)
Z Rate	Rad/second	float32	4	112	Spacecraft body angular Z rate (in spacecraft body frame)
Spacecraft Mode	N/A	uint8	1	116	7 – Orbit Maintenance Mode 8 – Payload Operations Mode
Manoeuvre flag	N/A	uint8	1	117	0 – None 1 – EP Firing 2 – Momentum Management 3 – EP Firing + Momentum Management
Payload Mode	N/A	uint8	1	118	0 - Off 1 - Bootloader 2 - Startup 3 - Operation 4 - Safe 5 - Test
SCID	N/A	uint16	2	119	Spacecraft Identification 104 - AWS PFM

Table 6-9 NAVATT packet structure.

ANNEX A CONVENTIONS

A.1 BIT NUMBERING CONVENTIONS

The bit numbering conventions shall be conform to [AD2] (ECSS-E-70-41C).

The following convention is used to identify each bit in an N-bit field:

- The first bit in a field, starting from the left, is defined as "Bit 0", and will be represented as the leftmost justified bit in a figure. The following bit is called "Bit 1", and so on, up to "Bit N-1", the bits being represented in this order from left to right in a figure

The following nomenclature is used to describe adjacent groups of bits within packets:

- 1 octet = 1 byte = 8 bits

A.2 FIELD ALIGNMENT CONVENTIONS

The following convention shall be used to construct packet parameter fields:

1. Parameters with a length longer than 16 bits shall be long word aligned, i.e. the LSB shall coincide with the long word boundary.
2. Parameters with a length of 16 bits shall be word aligned, i.e. the LSB shall coincide with the word boundary.
3. Parameters with a length shorter than 16 bits shall not be allowed to span over word boundaries.
4. Parameters with a length shorter than 16 bits but longer than 8 bits shall be right-adjusted within the 16-bit word.
5. There shall be no more than two numerical parameters (e.g. counters, analogue) inside a word; they should be right adjusted on the octet boundary.
6. Other non-numerical (Status Words, Booleans, enumerated) parameters may be packed tighter than according to 5), but no more than 3) allows.

A.3 DATA STRUCTURE

The following convention is used for the encapsulated data structure:

- Platform Telemetry / NAVATT: Big endian structure
- Instrument science packets: Little endian structure

ANNEX B VIRTUAL CHANNELS

B.1 DOWNLINK

The use of downlink Virtual Channels is described in the following table.

Table 6-10 VCID allocation for TM

VC ID (decimal)	Assignment	Radio band
0	Real-time S/C HK telemetry data	S-band
1	Stored S/C HK telemetry data	S-band or L-band
2	Stored S/C Science telemetry data	S-band or L-band
3	**DDB service** Real-time S/C Science telemetry data = Instrument science packets + NAVATT	L-band
4	Not used	
5	Not used	
6	Not used	
7	Idle frames	S-band and L-band

ANNEX C CYCLIC REDUNDANCY CODE (CRC)

A 16 bit CRC shall be used for telecommands and telemetry in conformance with [AD5] (ECSS-E-70-41C).

ANNEX D LINK BUDGETS

The DDB L-band link budget is established at 5 degrees elevation and clear sky conditions considering a ground station located in Stockholm, Sweden. Local users need to select the receiving antenna based on the link budget below adapted to the receiving location and its specific environment.

The Direct Broadcast Stations must be able to handle a maximum Doppler shift of +/- 43 kHz at an elevation angle of 5 degrees, and a Doppler shift rate of 0.18 kHz/sec at an elevation angle of 90 degrees.

Table 6-11 AWS DDB link budget at 5 degrees elevation

L-Band Downlink Budget @ 5degree elevation (DDB users)					
Input Parameters					
	Parameter	**NOM**	**ADV**	**FAV**	**Unit**
	Max communication distance	2317.15	2317.15	2317.15	km
	Orbit period	96.45	96.45	96.45	min
	antenna theta max	65.65			degree
Nominal Mode					
Base Band					
	brutto bit rate (coded)	3570.00	3570.00	3570.00	kbps
	User bit rate (uncoded)	1561.88	1561.88	1561.88	kbps
	Symbols	4			
	Modulation order	2			
	Symbol Rate	1785			kS/s
	Filter Factor	0.45			
	Bandwidth	5177			kHz
	Necessary BW	2106			kHz
	Doppler	43			kHz
Transmitter					
	TX carrier frequency	1.707	1.707	1.707	GHz
	TX output power	**3.30**	**3.30**	**3.30**	**W**
	RX power consumption (no TX)	2.73	2.86	2.60	W
	RX/TX power consumption (at TX)	22.00	22.00	22.00	W
	RX/TX average power consumption	22.00	22.00	22.00	W
	TX output power (dBW)	5.19	5.19	5.19	dBW
	TX output power (dBm)	**35.19**	**35.19**	**35.19**	**dBm**
	TX Harness loss	-0.50	-0.70	-0.30	dB
	TX antenna gain	0.00	-1.50	1.50	dBi
	Antenna Axial Ratio	1.50	2.50	1.00	dB
	Polarization loss	-0.09	-0.14	-0.06	dB
	Antenna VSWR	1.3	1.3	1.3	:1
	Antenna VSWR Loss	-0.07	-0.07	-0.07	dB
	EIRP (dBW)	**4.52**	**2.77**	**6.25**	**dbW**
	EIRP (W)	2.83	1.89	4.22	W
	EIRP (dBm)	34.52	32.77	36.25	dBm
Space and atmosphere					
	Free space loss	-164.39	-164.39	-164.39	dB
	Other losses (atmosph./rain)	-2.66	-2.66	-2.66	dB
Receiver					
	RX G/T @5deg	8.50	8.50	8.50	dB/K
	Antenna Axial Ratio	2.00	2.00	2.00	dB
	Navigation error (loss)	-0.10	-0.10	-0.10	db
	C/No	74.47	72.71	76.20	dB-Hz
	Eb/No	**12.53**	**10.78**	**14.26**	**dB**
	Channel coding	VR	VR	VR	
	Required Eb/No (uncoded)	2.60	2.60	2.60	dB
	Tx Implementation loss	1.00	1.00	1.00	dB
	Rx Implementation loss	0.50	0.50	0.50	dB
	Required Eb/No (net)	4.10	4.10	4.10	dB
	Margin	8.43	6.68	10.16	dB
	Required margin	3.00	0.00	3.00	dB
	Margin - Required margin	5.43	6.68	7.16	dB

ANNEX E ANTENNA PATTERN

The stand-alone L-band antenna radiation gain pattern is presented in this section (as measured).

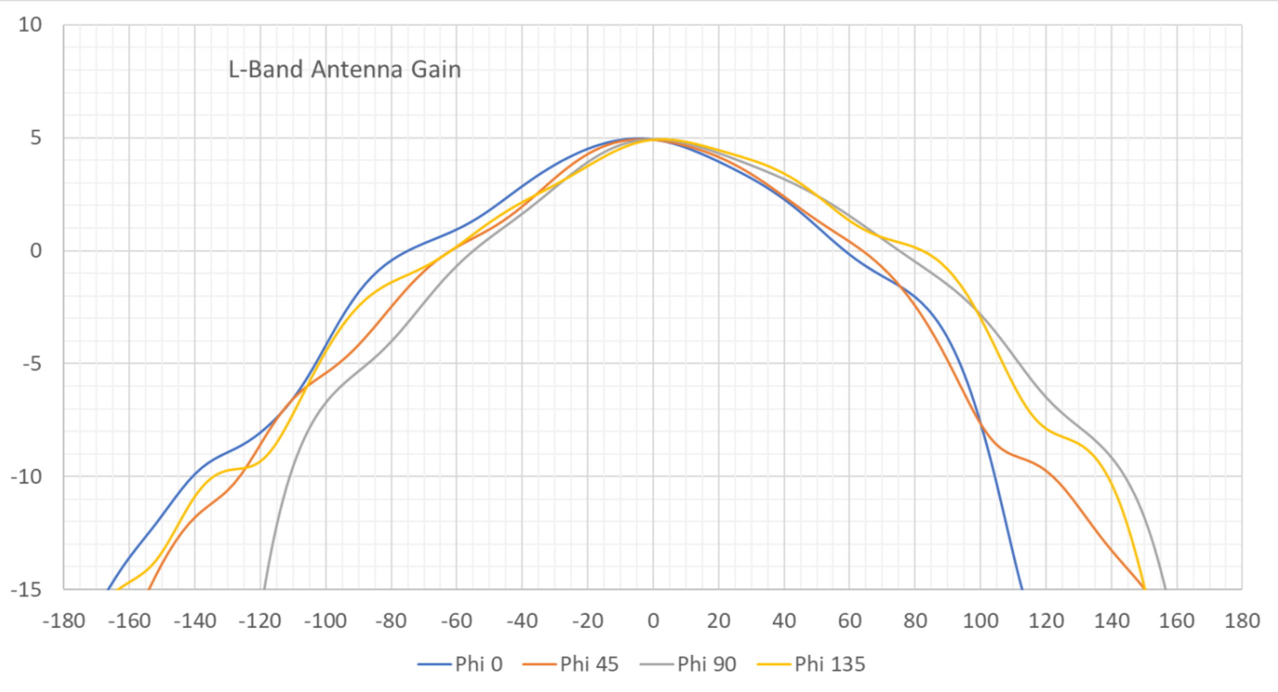


Table 6-12 Co-polar (RHCP) realized gain over elevation (θ) for different azimuth (φ)

ANNEX F IDLE DATA DESCRIPTION

For idle data (added at TCM level), 0x5A is the data sent for Idle Frames and Idle Packets.

ANNEX G SPACECRAFT IDENTIFICATION (SCID)

The Spacecraft Identification (SCID) is assigned by the Space Assigned Numbers Authority and is mission specific.

Table 6-13 - SCID

Spacecraft name	Spacecraft CCSDS ID	Spacecraft international COSPAR ID
AWS PFM	x068 (104 dec)	202x-xxxx
AWS-2	TBD	
…		
AWS-16	TBD	