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DOCUMENT

GS inputs to on-board data architecture

European Space Agency
Agence spatiale européenne

APPROVAL

Title GS input to on-board data architecture	
Issue 2	Revision 0
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CHANGE LOG

Reason for change	Issue	Revision	Date
First issue	1	1	06-Nov-2014
Added req on PVT and Quaternions frames	1	2	12-Dec-2014
Clarified APID vs PUS usage	1	3	12-Mar-2015
Customised for CFDP	1	4	12-Dec-2018
Update with comments from EOP-G	1	5	05-Apr-2019
Document maintenance following BIOMASS experience	1	6	05-May-2020
Update for re-distribution as generic req.	1	7	15-02-2022
Amended after review for TRUTHS and FORUM	1	8	13-10-2023
Amended after review for Harmony	1	9	23-11-2023
Amended following discussions in Forum	2	0	07-03-2025

CHANGE RECORD

Issue 1	Revision 1		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
First issue	06-Nov-2014	all	

Issue 1	Revision 2		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Added req on PVT and Quaternions frames	12-Dec-2014	8	

Issue 1	Revision 3		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Clarified APID vs PUS usage (added req 19 and 20)	12-Mar-2015	8	

Issue 1	Revision 4		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Renumbering of requirements	12-Dec-2018	all	
Evolution to support use of CFDP	12-Dec-2018	all	
Clarification of RAW and Level 0 product	12-Dec-2018	4	

Issue 1	Revision 5		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Corrections of typos and clarifications	05-Apr-2019	all	

Issue 1	Revision 6		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Update to req. numbering into separate groups Clarification on ancillary generation.	05-May-2020	all	

Issue 1	Revision 7		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Update header with ESA classification	15-Feb-2022	all	
Update comments on CFDP	15-Feb-2022	all	

Issue 1	Revision 8		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Additional definition in Glossary	13-Oct-2023	Section 1	
Rewritten section on CCSDS Space Packet: Reworded ambiguous requirements Negative requirements re-worded as positive Sorted the requirement per topic in dedicated subsections Removed requirement on SSC continuity as it is already part of CCSDS standard Renumbered the Requirements	13-Oct-2023	Section 4.1.1	

Issue 1	Revision 9		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Terminology clean-up	23-Nov-2023	all	
Removed Glossary	23-Nov-2023	5	
Simplification of introductory section	23-Nov-2023		Section 1
Removal of figures	23-Nov-2023		Section 1
Clarification of CFDP terminology to only refer to payload data and not to TT&C ones	23-Nov-2023		Section 3.1.3

Issue 2	Revision 0		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
Added Requirements 16, 55 and 78	07-03-2025		
Amended req. 70	07-03-2025		

Table of contents:

1 PURPOSE AND SCOPE

This TN contains a list of inputs to define an on-board data architecture that allows an efficient, standardised payload CCSDS data analysis, data generation, data simulation, algorithm development and data processing on ground.

(NB it does not apply to TT&C/S-Band data links).

This TN also addresses the specificity introduced by the use of CFDP in addition to the pure Space Packet Protocol to ensure Space to ground data transfer. It is noted that CFDP has never been used in EO mission and that the operational profile of EO related to payload data downlink differs from the one used in Space Science, both on the technical level (many short passes) as well as programmatically (Payload data ground station acquired as service from external providers and not operated by FOS).

The requirements contained in this document comply therefore with the applicable CCSDS standards either the traditional CCSDS Space Packet or the newer CFDP, concepts and rationale; furthermore take into accounts the specificity of a typical EO mission data processing ground segment whereby:

- a multiplicity of physical or logical on-board sources generate data to be processed on-ground
- the data is produced by each source (Application) in data units formatted as :
  - Space Packets
  - CFDP Files containing Space packets
  - CFDP Files containing data formatted in a Project-specific fashion
- CFDP Layer uses as *Unitdata Transfer layer (UT)* the Space Packet Protocol.
- the same physical on-board source (instrument) produces measurement data in different modes (e.g. Calibration, Nominal, dual, interferometric, reduced, test, etc) that need to be processed differently
- on-board sources, different from the instrument, produce ancillary data (e.g. Navigation or Thermal data)
- the different Space Packets types are identified via their Primary Space Packet Header
- different types and instances of CFDP files are identified via their name.
- the different Space Packets types are processed on ground by the same or different data sinks
- different types of CFDP files are processed on ground by the same or different data sinks
- the end-to-end application level routing from on-board source to ground segment sink is performed based on the Primary Space Packet Header or based on the CDFP file type as identified by means of its name.
- common commercially available Ground Station Equipment conforming to CCSDS concepts (Demodulator and FEPs) is used with no modification.
- the end-consumer/sink of each data unit is the corresponding Level-1 Processor for each type of data product. (see Fig. 2)
- the Payload data downlink is executed preferably in a full open loop concept and the need of uplink to control CFDP operation during a Payload Data downlink is avoided[1].

These inputs (which are phrased as requirements) should be made applicable to the Space Segment for all the on-board data structures (i.e. CADU, TF, ISP, PDU, CFDP Files), which will then be downloaded to ground for processing or explicitly waived for a specific project (with a sound justification).

2 REFERENCE DOCUMENTS:

[CCSOVP]	Overview of Space Communications Protocols, CCSDS 132x0b1
[CCSTMR]	TM Rationale, CCSDS 100x0g1
[CCSDLP]	TM Space Data Link Protocol CCSDS 132x0b1
[CCSADL]	AOS Space Data Link Protocol CCSDS 732x0b2
[CCSSLI]	Space Link Identifiers CCSDS 135x0b3
[CCSTMS]	Telemetry Services, CCSDS, 103.0-B-2
[CCSFDP]	CCSDS File Delivery Protocol (CFDP) CCSDS 727.0-b4
[CCSUDL]	Unified Space data Link Protocol, CCSDS 732.1-b1
[PUS]	ECSS Packet Utilisation Service
[L0RAW]	EO generic RAW and L0 specification, PE-TN-ESA-GS-586

3 INPUTS

The requirements/inputs here below address separately the various CCSDS communication layer and the corresponding Data Units.

3.1.1 CCSDS Space Packets

3.1.1.1 Application Data Definition and Identification

R-01 The CCSDS Space Packet APID and the Source Sequence Counter within the Space Packet Header shall be used for the unique identification of the Application Data Unit type (the Space Packet) and for their end-to-end routing and sorting in the Ground Segment.

R-02 On a given satellite, the APID, for each packet type, shall be unique even if these packets are downlinked in different physical RF channel (e.g. S and X band) or are transmitted via different Virtual Channels.

R-03 The content of each observation Space Packet shall be defined so that the information in the Packet Secondary Header, in the Space Packet Data Field or in separate ancillary packets shall not be needed to determine the data type, routing or to select the algorithm/processing chain/facility.

R-04 Each instrument measurement mode requiring a different (ground) processing or ground routing shall be assigned a different APID. This includes, in particular, APID-differencing between different internal calibrations, different external calibrations and different observation measurement modes (e.g Dual/full polarisation, wide/narrow swath, etc etc).

R-05 All the Platform ancillary parameters needed for scientific/mission data processing (e.g. PVT, attitude, etc) shall be contained in dedicated independent ancillary Space Packets and not included within the observation data packet.

R-06 All the Instrument ancillary parameters needed for scientific/mission data processing shall be contained in dedicated, independent ancillary Space Packets and not shared with the TT&C HKTM monitoring packet (even if this results in having duplicated information between HKTM and Scientific/mission data).

R-07 The CCSDS Space Packets containing ancillary data set generated on board by different sources e.g. by the Platform or by the Instrument, shall be distinct and have each a different APID (e.g.

Navigation ancillary Space Packet shall have different APID from Thermal acquisition Space Packet)

3.1.1.2 Structure and format

R-10 All Space Packets needed for ground processing and including ancillary, measurement and calibration shall include a Space Packet secondary header (also called data field header) common across all packet types and formatted either according to PUS or according to CCSDS.

R-11 All Space Packets needed for ground processing including ancillary, measurement and calibration shall contain in their Space Packet secondary header a time stamp with a single format across all packet types, a common Epoch and common position of the corresponding bitfield within the data, even if originated by different on-board clocks or sources.

R-12 All the parameters in the Space Packets needed for scientific/mission data processing shall not be subcommutated (i.e. the same position inside a packet shall contains for the same APID always *exactly* the same parameter)

R-13 Space Packets with the same APID shall have the same data field structure even when segmentation/grouping is used.

R-14 Whenever the packet structure for payload data is formatted according as PUS, the Service Type/Subtype field shall be ignored and not be used in the place of the APID to discriminate different type of data.

R-15 The packet structure of payload data shall not make use of SID, i.e. a packet with a given APID shall always have the same physical structure and parameter content.

R-16 The generated CCSDS Space Packets shall have a length to exactly contain the valid data i.e. not padding the Data Field in case data is shorter or of variable in size.

3.1.1.3 Navigation Data

R-20 The PVT information located in platform ancillary Space packets (sometime called NAVATT) used for data processing shall be expressed in **Earth Fixed** frame of reference in accordance to the one used by the GNSS units.

R-21 The attitude (quaternions) information located in platform ancillary space packet (sometime called NAVATT) used for data processing shall be expressed in **inertial** frame of reference according to the one used by the AOCS.

R-22 The baseline frequency of PVT data transmitted on ground shall be OSV at 1 Hz.

R-23 The baseline frequency of attitude data available on ground shall be Quaternions at 1 Hz assuming no on-board perturbation at higher frequency are present, however in specific cases a higher frequency might be warranted Absolute Pointing Knowledge (APK) requirements.

R-24 (goal) OSV and Quaternions with the same frequency shall be sampled and be associated at the same moment in time.

3.1.1.4 Ancillary Data availability

R-30 All the ancillary packets generated by the platform on-board (e.g. NAVATT, Thermal, etc) shall be available for downlink via the Payload data link regardless of the mode and state of the instrument i.e. also when the instrument is not measuring, in standby or OFF ensuring availability on ground also outside the measurement interval.

3.1.2 Space Data Link (Transfer Frames) and multiple RF channels

R-50 (goal) The AOS Transfer Frame structure [CCSADL] shall not make use of the insertion zone

R-51 Idle Space Packets generated to complete a TF shall be correctly formatted including in particular their length field and the APID set to 0x7FF.

R-52 Separate Virtual Channels shall make use of separate, independent Virtual Channel Frame Count.

R-53 In case more than one physical RF channel is used to downlink the Mission Data, the downlink of a specific packet store (allocated to a VC) shall not be split between different physical channels.

R-54 In case more than one physical RF channel is used to downlink the Mission Data it shall be possible to configure each packet store (using the VCID as key) to be downlinked on a specific physical channel.

R-55 Fixed size CCSDS Transfer Frames shall be complete/padded when needed only using valid CCSDS Space Packets (idle or mission defined)

3.1.3 CFDP

R-70 The payload CFDP files shall be identified by a unique filename compliant with [RAWL0].

R-71 The filename of each payload on-board file shall allow to fully identify file type and instance to allow proper on-ground routing to relevant processing facility without requiring inspection of file content.

R-72 Each payload CFDP file shall contain either only Space Packets or only mission-specific sequence of octets and not a mixture of the two

R-73 In case different types of data are requested to be processed independently and the same VCID is used, the corresponding CFDP PDU shall be tagged with a different CFDP “DestinationID” (e.g. HKTM and Payload data)

R-74 The payload CFDP entity on-board shall allow to define a configurable priority for the download order of various data type and age.

A typical default file download order is

1. TM-Files “Housekeeping TM” from oldest to latest (if HKTM is transmitted on the payload data link)
2. ancillary data files (Instrument and Platform)
3. Science Data Files. The assumed download order for science files is typically from oldest to newest;

R-75 (goal) the on-board payload data handling system and overall operational concept shall be designed if possible to ensure the required performance and data availability with an open-loop (CFDP Class-1) approach.

R-76 The on-board data handling system shall allow to autonomously issue CFDP.suspend and CFDP.resume service directive controlling the file payload data downlink only within ground station visibility with configurable margin.

R-77 When considering unreliable links and the use of CFDP Class-1, the CFDP file size shall be selected (small enough) such that considering the statistically expected RF link outages the amount of lost data at the end of each pass is minimised.

3.1.4 Other

R-90 It shall be possible at any point in time to command and initiate the downlink all the data stored in the on-board payload mass memory regardless of the data size and of the way the data is stored on-board and the memory managed (e.g. also when the data is stored in incomplete memory pages, sectors, etc).