Herschel PACS

DPU On Board Software User Requirements Document

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Contents

Document Status Sheet

Document Title: Herschel PACS DPU On Board software User Requirement Document			
Issue	**Revision**	**Date**	**Reason for change**
Draft 0		5th November 1999	First draft for each instrument
Draft 1		29th November 1999	Merged the three URD in only one document by IFSI
Draft 2		31st March 2000	Inserted comments from the three consortia
Draft 3	1	13rd June 2000	SPIRE section updated. Common section updated in accordance with the new versions of the applicable documents
Draft 3	2	30th June 2000	PACS section updated
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2	0	11th January 2002	Updated taking into accounts new versions of the documents
2	1	15th September 2004	Version to be delivered to CGS (Software Version 1)
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Document Change Records

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Section	**Reason For Change**
1.2.1	List revised
2.1	Upgraded
2.2	Upgraded
3	Upgraded
3.1.1	OBS-CUR-TC3: clarified
3.1.1	OBS-CUR-TC16: upgraded
3.1.1	OBS-CUR-TC17: deleted
3.1.1	OBS-CUR-TM12: deleted
3.1.1	OBS-CUR-TM18: deleted
3.1.1	OBS-CUR-TM19: modified
3.1.1	OBS-CUR-TM20: deleted
3.1.1	OBS-CUR-SM9: deleted
3.1.1	OBS-CUR-AF8: deleted the note
3.2.1	OBS-PUR-GE4: deleted
3.2.1	OBS-PUR-GE5: deleted
3.2.1	OBS-PUR-GE6: deleted
Appendix A	Removed column with status (all requirements are implemented)

[· · ·]
quod super est, vacuas auris animumque sagacem
semotum a curis adhibe veram ad rationem
ne mea dona tibi studio disposta fideli,
intellecta prius quam sint, contempta relinquas.
Lucreti de rerum natura libri sex

1 Introduction

This document contains the User Requirements of the DPU On Board Software for the Herschel/PACS instrument.

PACS can be broken down in sub-units called subsystems, each with its own CPU and on board software. The user requirements for these subsystems are out of the scope of this document: they are here considered only if sources of requirements for the DPU software.

When the DPU is switched on, a bootup SW executes the procedure described in AD9. In that document the requirements on this boot SW are reported. The OBS to which this URD applies starts its execution when the procedure resident in PROM has been completed.

1.1 Purpose of the document

The user requirements in a software development lifecycle are the result of the problem understanding phase and reflect the needs of the “users” who will finally use the software. This document aims at clarifying and at collecting these needs in order to correctly implement them. In our case, the software to be developed will have the main purpose of interfacing with the CDMS and of handling the various subsystems of the three instruments which will be part of the payload of the Herschel satellite.

For the SW development PACS adopts the standard given in AD1 tailored to be fully equivalent to RD1.

1.2 Acronyms and abbreviations

1.2.1 Acronyms

AOT Astronomical Observation Template
APID Application Identifier
CASE Computer Aided Software Engineering
CDMS Command and Data Management System
CGS Carlo Gavazzi Space
CNR Consiglio Nazionale delle Ricerche
CPU Control Processing Unit
CSL Centre Spatial de Liège
DEC Detector Controller
DPU Digital Processing Unit
EEPROM Electrically Erasable Programmable Read Only Memory
ESA European Space Agency
HIFI Heterodyne Instrument for FIRST
HK HouseKeeping
HW HardWare
ICC Instrument Control Centre
ICD Interface Control Document

ICS Instrument Command Sequence
ICU Instrument Control Unit
IFSI Istituto di Fisica dello Spazio Interplanetario
INAF Istituto Nazionale di Astrofisica
MEC Mechanical Control unit
MOC Mission Operations Centre
NTBT Not To Be Traced
OBS On Board Software
OIRD Operations Interface Requirements Document
PACS Photoconductor Array Camera and Spectrometer
PROM Programmable Read Only Memory
RAM Random Access Memory
ROM Read Only Memory
SPIRE Spectral and Photometric Imaging Receiver
SPU Signal Processing Unit
SW SoftWare
TC TeleCommand
TM TeleMetry
UR User Requirement
URD UR Document
UTC Universal Time Co-ordinated
UVIE University of Vienna

1.2.2 Abbreviations

ID Identification

1.3 References

1.3.1 Applicable documents

Ref.	Name	Number/version/date
AD1	Space engineering - Software - Part 1: Principles and requirements	ECSS-E-40 28 November 2003
AD2	Herschel/Planck Instrument Interface Document Part A	SCI-PT-IIDA-04624 Issue 3/1. 12 February 2004
AD3	Herschel/Planck Instrument Interface Document Part B. Instrument “PACS”	SCI-PT-IIDB/PACS-02126 Issue 3/2. 2 March 2004
AD4	Herschel/Planck Operations Interface Requirements Document	SCI-PT-RS-07360 Issue 2.2. 31 September 2003
AD5	Herschel/PLANCK Packet Structure Interface Control Document	SCI-PT-ICD-07527 Issue 5. 20 July 2004
AD6	FIRST Instrument Commanding Concepts	Draft 1. 22 October 1999
AD7	Operating modes of the PACS Instrument	PACS-ME-PL-005 7 December 1999
AD8	DPU/ICU On Board Software Product Assurance Plan	IFSI/OBS/PL/2000-001 Issue 1.1. 2 April 2001
AD9	DPU/ICU Switch-on Procedure	CNR.IFSI.2001TR01 Issue 1.0. 12 October 2001

1.3.2 References documents

Ref.	Name	Number/version/date
RD1	Guide to applying the ESA software engineering standards to small software projects	BSSC(96)2 Issue 1. May 1996
RD2	PACS DPU subsystem specification document	Issue 1.2. 15 January 2002
RD3	Telemetry and Telecommand Packet Utilisation Standard	ECSS-E-70/41 Draft 04 April 1999
RD4	Interface Control Document DEC/MEC–DPU	PACS-CL-ID-003 Issue 3.5. 3 October 2003
RD5	SPU OBS URD	PACS-TW-SR-001 Issue 6.0. 13 December 2005
RD6	LFI-REBA and PACS-SPU Start-up SW and Low Level SW Drivers URD	PACS-IC-RD-001.01 22 January 2001
RD7	DEC/MEC Software URD	PACS-CL-SP-001 17 February 2000
RD8	List of PACS Housekeeping and Telecommands	PACS-ME-LI-005 Issue 1.3. 6 April 2006
RD9	AxiomSys User's Manual	©1992-1999 by Structured Technology Group, Inc.

1.4 Overview of the document

The DPU On Board Software User Requirements document is organised as follows:

Section 1 (this section) contains the introduction, with a brief description of the purpose of the software providing the "reading tools" (list of acronyms, references and so on)

Section 2 provides a general description of the world the software operates in

Section 3 reports the list of all the requirements upon which the software will be accepted

2 General description

2.1 General capabilities

Figure 2-1 gives an overview of the activities of the OBS. The DPU is the only data interface of the instruments with the satellite, so the main capabilities of the OBS will be related with TCs and TM handling. In particular, TCs packets will be received, checked, and executed, if specific for DPU, or translated into appropriate commands instructions and sent to the subsystems. The DPU will then receive the science data and all the HK data, which are used for monitoring the instrument behaviour. A check will be performed on some of the parameters and, if the corresponding critical values are reached, the OBS will run the pre-defined autonomy functions in order to prevent any damage to the instrument. Depending on the severity of the detected anomaly, the measurement could be reset and/or DPU could ask CDMS to set an instrument to standby mode and/or to switch off an instrument or some of its subsystems.

TM will be structured in packets according to AD5. The main identifier of the packet is the APID, different for nominal/redundant unit and, for the same unit, different for science data, for HK packet and for all the other packets (events, memory management, TC verification and so on). Furthermore, the OBS has to manage the uploading and downloading of (part of) the processor memory: this will allow to upgrade the OBS as well

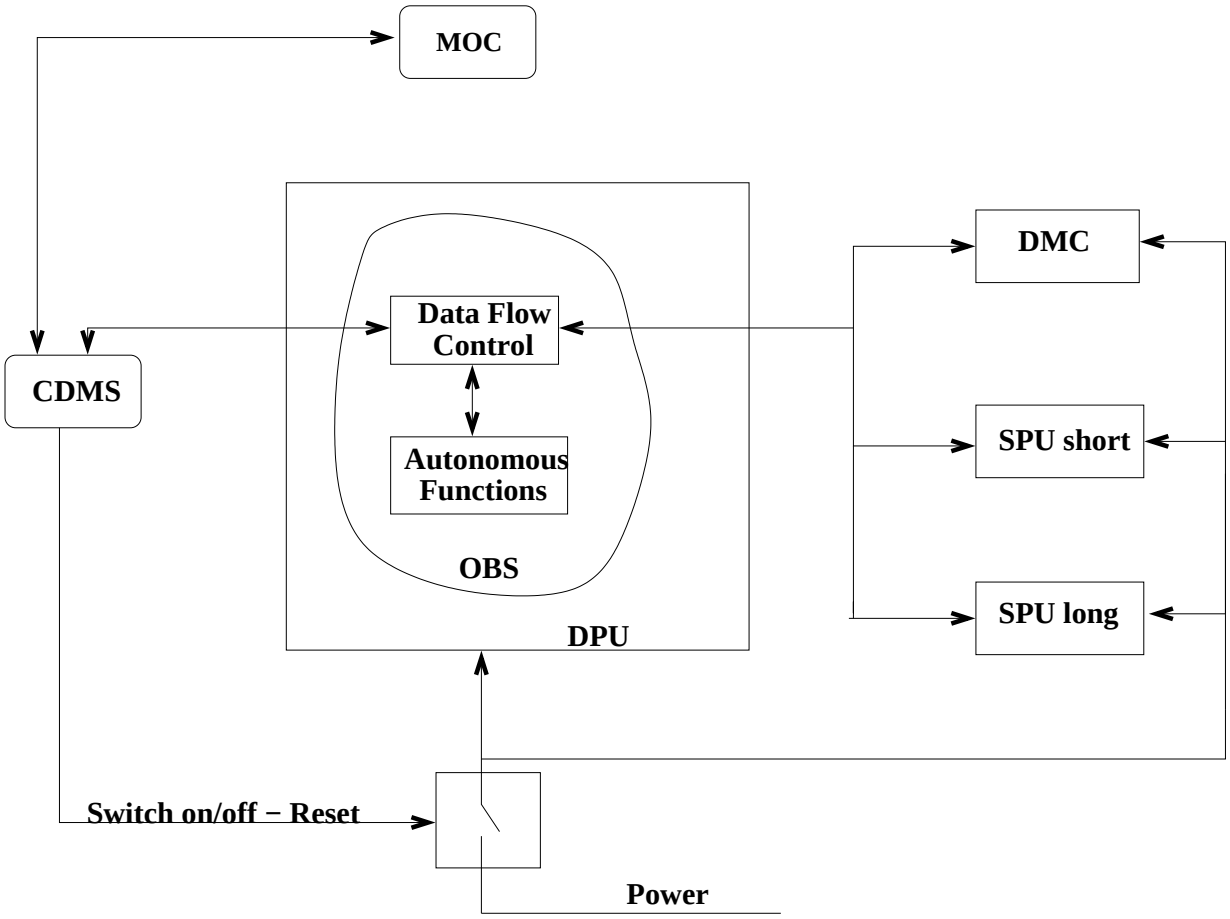

Figure 2-1: *High level functionality of DPU OBS: dialogue with subsystems and check of health status of the instrument (autonomy functions). On the base of the HK parameters values DPU can ask the CDMS to switch off part or the whole instrument. To simplify the figure only one power line has been drawn: actually, each susbsytem can be switched on/off independently by the spacecraft.*

as all the subsystems parameters tables. The PACS subsystems run their own programs which will likely need upgrades: OBS will be in charge of receiving these memory images and passing them to the appropriate subsystem.

For each instrument, basic operating modes will be defined. The OBS will be able to handle the instrument behaviour in all of them. The modes are described in AD7.

2.2 General constraints

- Ground Contact during the routine science mission phase:

  ground station contact and real time control will take place during 3 hours per day (AD2 Sect. 4.2). This means that the science operations will be done outside a ground control. The activities on board will be performed from a schedule, but autonomy. In particular, the instrument will need on board monitoring and autonomy features to recover from non nominal situations: this might require to request the CDMS to switch off the instrument. It is decided that while an autonomy function can lead to the switch off of an instrument, the following switch-on can take place only during ground contact.

- Interfaces constraints:
  - Serial spacecraft interface MIL-STD-1553B. Main characteristics:
    1. Fundamental unit of data is a 16 bit word
    2. This unit of data is encoded into 20 bits on the bus (allowing HW to detect transmission errors)
    3. The only controller of the bus is the CDMS
    4. Clock rate is 1 MHz
    5. Nominal bit rate is 130 kbps, averaged on 24 hours, including HK, events and TC verification
    6. Burst mode bit rate is 300 kbps, maximum period of 30 minutes in 24 hours
    7. Each command is a transmit or receive command. A command has 1-32 words (16 bit)
  - Serial interfaces with subsystems: see instrument specific subsections.
- Microprocessor (DSP21020):
  - Program bus: 48 bits
  - Data bus: 32 bits
  - Memory dimensions:
    - PROM = 32 kB
    - EEPROM = 1 MB (256k x 32 bit)
    - Program RAM = 3 MB (512k x 48 bit)
    - Data RAM = 2 MB (512k x 32 bit)
  - Clock speed ($\simeq$ 20 MHz)

2.3 User characteristics

The natural users of the software will be:

- The ICC personnel in charge of the command uplink sequence definition, who will provide the command procedures related to the measurements to be performed;
- The SW engineers, who will perform the testing, maintenance and upgrading of the software all over the satellite lifetime;
- The Ground Test (instrument and system level) Engineers, who will perform the functional and performance test on instrument before launch
- The other instrument subsystems developers, who will provide requirements mainly on the software interfaces and performances.

2.4 Operational environment

The DPU will interface with the spacecraft through a serial interface compatible with the MIL-STD-1553B. The communications with the other subsystems will be done through a serial interface according to 1355 standard. The microprocessor for DPU is the Analog Devices 21020, developed for space applications by TEMIC.

The OBS will be developed in the following environment:

- Virtuoso[1] as operating system
- AxiomSys[2] as structured analysis based CASE tool
- SIGMA[3] 33MHz ADSP 21020 development board for SW testing

3 Specific Requirements

The main functions of the OBS are:

- Acceptance of instrument commands from the CDMS;
- Execution of predefined ICSs;
- Instrument health/status monitoring;
- Implementation of pre-defined procedures on detection of instrument anomalies: the instrument shall be able to adjust parameters and/or switch operating mode;
- Science data acquisition from SPU and packetisation;
- HK data acquisition from all units and packetisation;
- Transmission of all TM packets from the instrument to the CDMS;

In addition, the OBS shall provide the following SW oriented functions:

- The ability to load, via TCs, replacement and/or additional SW;
- Self test and SW verification facilities;
- Possibility to load, dump and check DPU memory;
- Possibility to write and check EEPROM.

The above listed functions all together lead to the definition of the following lists of requirements, which have been classified as: switch on, switch off, TCs handling, TM generation, synchronization, SW testing and maintenance, autonomy functions and TM rate. These requirements are reported in Section 3.1; Section 3.2 contains requirements specific to the interface with PACS subsystems

The acceptability of the SW will be assessed with respect to the specific requirements listed below.

3.1 Common requirements

Each requirement is uniquely identified by its ID code according to the following template: **OBS-xUR-yyii**. The letter x can be C (requirements specific to the DPU as a whole), or P (requirements on the SW interface with subsystems). The third token consists of a string (yy) and a two digits progressive index (ii). The string can assume one of the following values:

ON switch on/reset requirements

[1] Virtuoso is a trademark of WindRiver
[2] AxiomSys is a trademark of Structured Technology Group, Inc.
[3] Sigma board is manufactured by BittWare research systems

OF switch off requirements

TC TCs requirements

TM TM generation requirements

SY synchronization requirements

SM OBS testing and maintenance requirements

AF autonomy functions requirements

TR TM rate requirements

GE general

3.1.1 Capability requirements

Switch-on requirements

Req. ID	Description	Reference
OBS-CUR-ON1	The DPU shall support the switch-on procedure described in AD9	NTBT

Switch-off requirements

Req. ID	Description	Reference
OBS-CUR-OF1	The DPU shall support the switch-off procedure described in AD7	NTBT

Telecommands requirements

Req. ID	Description	Reference
OBS-CUR-TC1	The OBS shall be able to handle the following types of commands: a) send a measurament instruction to the other subsystems; b) execute a function/sequence in the DPU; c) execute an OBCP in the DPU The list of commands implemented by the DPU is reported in RD8	AD6
OBS-CUR-TC2	The OBS shall be able to: a) update/add a SW function; b) update/add a procedure	AD6 Sect. 3.2.2

Req. ID	TCs requirements (ctd)	Reference
OBS-CUR-TC3	The OBS shall accept all the instrument commands originated from the CDMS. The commands are issued as TC packets structured following the definition reported in AD5 **Note**: *the DPU is not meant to buffer TC since it is responsability of ground to ensure a proper mission timeline. However the SW design ensures that one, and only one, TC can be buffered while the previous one is still under execution*	AD4 Sect. 1.5.1
OBS-CUR-TC4	The OBS shall receive, unpack and process all the uplinked TC packets at the maximum command data rate (2 TC per second, AD2 Sect. 5.11.4, during nominal operations), regardless of packet sizes. For test purposes the TC data rates could be higher **Note**: *processing the TC packets does not imply executing the command*	AD4 Sect. 2.1.1 CTRL-5, CTRL-6
OBS-CUR-TC5	The OBS shall acknowledge, using TM report packets, the receipt of the TCs. A specific field in the acknowledgement area (header) will indicate what type of acknowledgement (if any) is needed for each TC	AD4 Sect. 3.2 TCV-0 AD5 Sect. 3.1.2.1
OBS-CUR-TC6	The OBS shall avoid that the reception, processing and execution of TCs affects any other independent on board process, unless the received TC is an immediate command (e.g. Abort)	AD4 Sect. 2.1.2 TC-8
OBS-CUR-TC7	The OBS shall be able to check the conformity of the received packets according to the standard given in AD5, to check their integrity and to reject non-valid packets	AD4 Sect. 3.1 PACK-14 AD5 Sect. 3.1.2.1 AD6 Sect. 4.3
OBS-CUR-TC8	The OBS shall reject non-valid packets at the earliest possible stage in the on board acceptance and execution process. The related ICSs shall not be executed at all	AD4 Sect. 2.1.2 TC-7 AD6 Sect. 4.3
OBS-CUR-TC9	The OBS shall generate a report indicating the result of the acceptance of the received TC packet. In case of non valid packets, this report shall include the reason for not acceptance	AD4 Sect. 3.2 TCV-1, TCV-2
OBS-CUR-TC10	The OBS shall generate the TC verification report at the earliest possible stage in the on board acceptance and execution process	AD4 Sect. 3.2 TCV-7
OBS-CUR-TC11	The OBS shall transmit the commands to the relevant subsystems of the instruments	AD3
OBS-CUR-TC12	The OBS shall be able to generate, on request, a progress report or anomaly report reflecting the completion status (success or failure) of the stages of the TC execution process **Note** (from IFSI): *this requirement applies only to the services contained in AD5 that require it (like memory management service)*	AD4 Sect. 3.2 TCV-3

Req. ID	TCs requirements (ctd)	Reference
OBS-CUR-TC13	The OBS shall generate a TM packet for unsuccessful command execution	AD4 Sect. 3.2 TCV-4
OBS-CUR-TC14	The OBS shall be able to abort the execution of an OBCP whenever a special control TC is received	AD6 Sect. 4.1
OBS-CUR-TC15	The OBS shall support the possibility of updating, via dedicated TCs, all the parameters tables stored on board	AD4 Sect. 3.2 TC-9
OBS-CUR-TC16	The OBS shall interrupt, if requested, the transmission of TM packets to the CDMS **Note** (from IFSI): *the OBS will ignore any request to disable TM packets (1,1) and (1,2) (TC Acceptance Report - Success/Failure), as well as the essential HK packet*	AD4 Sect. 3.2 TCV-5

TM generation requirements

Req. ID	Description	Reference
OBS-CUR-TM1	The OBS shall pack all the packets according to the ESA TM standards	AD5 Section 4.1
OBS-CUR-TM2	The OBS shall be able to acquire the science data provided by the other subsystems and to transmit them to the CDMS following the protocol defined in AD5 Appendix 9	NTBT
OBS-CUR-TM3	The OBS shall be able to collect the HK data provided by the other subsystems and by the DPU itself during all nominal modes of the instrument, including any instrument SAFE mode. This requirement does not apply in specific non-nominal mode (as processor halted/reset)	AD4 Sect. 2.1.1 CTRL-4
OBS-CUR-TM4	The OBS shall be able to analyse the collected HK parameters according to operating mode and limit check criteria	AD4 Sect. 2.1.1 CTRL-4
OBS-CUR-TM5	The OBS shall packetise the collected HK parameters into dedicated output TM packets. A nominal HK TM packet will be defined for each instrument mode, containing all the relevant parameters. The structure of this predefined TM packet shall be available on board	AD4 Sect. 3.2 TCV-9 AD4 Sect. 3.4.1 PERP-6 AD6 Sect. 4.5.1
OBS-CUR-TM6	The TM packets shall report the APID according to AD5	AD4 Sect. 3.1 PACK-0
OBS-CUR-TM7	In different modes of the instruments, some of the parameters to be reported into the nominal HK packet will not be valid. The OBS shall be able to clearly indicate in the packet which are the valid parameters **Note**: *this requirement is not applicable to DPU becaues its own HK are always valid. It is applicable to the subsystems HK*	AD4 Sect. 3.1 PACK-3 AD6 Sect. 4.5.1
OBS-CUR-TM8	The OBS shall be able to provide the nominal HK TM packet (with a pre-defined content) at a normal reporting rate of 0.5 Hz	AD4 Sect. 3.1 AD4 Sect. 3.4.1 PERP-6 AD6 Sect. 4.5.1

Req. ID	TM Generation requirements (ctd)	Reference
OBS-CUR-TM9	The OBS shall be able to modify, accordingly to dedicated TCs, the pre-defined sets of HK parameters to be included into the HK/diagnostic TM packet **Note**: *this requirement is only applicable to DMC, DPU shall support reception of HK diagnostic packets from DMC*	AD4 Sect. 3.4.1 PERP-5
OBS-CUR-TM10	The OBS shall be able to include in the TM packets used to monitor the SW status all the commandable parameters used by the executed OBCP	AD4 Sect. 2.1.3 TM-10
OBS-CUR-TM11	The OBS shall provide only actual values of the HK parameters and not changes (or delta values) since the last readout: the *filtered* reporting mode is not allowed (the DPU will assume that the values sent by the other subsystems are actual values and not delta values)	AD4 Sect. 2.1.3 TM-11
OBS-CUR-TM12	The OBS shall be able to generate additional types of HK TM packets related to specific operational modes or configurations	AD5 Sect. 5.3
OBS-CUR-TM13	The DPU shall transmit the request of generating additional HK packets containing oversampled data to DEC/MEC which is in charge to sample the values with the specified frequency. The DPU will generate the TM packet without checking that the DEC/MEC actually sampled the parameter(s) with the correct frequency	AD4 Sect. 3.4.1 PERP-4 AD6 Sect. 4.5.1
OBS-CUR-TM14	The OBS shall produce science data packets which will contain sufficient information to allow the data processing without the necessity to refer to HK TM to derive subsystems parameters. The set of subsystem parameters is sent to the DPU by the SPU. The DPU transmits it to the CDMS without any processing	AD6 Sect. 4.5.2
OBS-CUR-TM15	The OBS shall be able to provide a time info in the header of all output TM packets. The meaning of this time info depends on the specific service type/subtype	AD4 Sect. 2.1.3 TM-17 AD4 Sect. 3.1 PACK-11, PACK-12 AD6 Sect. 4.5
OBS-CUR-TM16	All science, nominal HK and event packets shall report information identifying to which observation they belong	AD5
OBS-CUR-TM17	The OBS shall be able to buffer TM packets until they are requested by the CDMS. The dimension of the buffer is 400 packets for science, 64 for HK and 32 for events. In case a science buffer overlow occurs, the OBS shall ensure that the CDMS will be informed through a specific event packet	NTBT

Synchronization requirements

Req. ID	Description	Reference
OBS-CUR-SY1	The OBS shall be able to synchronise and to verify the DPU internal clock with the CDMS master clock	AD4 Sect. 1.5.8 AD4 Sect. 2.1.4 TIM-1 AD4 Sect. 3.8 OBTM-4

Req. ID	Synchronization requirements (ctd)	Reference
OBS-CUR-SY2	The OBS shall flag, after switch on or reset, each packet (in the header time field) whenever the time has not yet been synchronised	AD4 Sect. 2.1.4 TIM-4 AD4 Sect. 3.8 OBTM-5
OBS-CUR-SY3	Timing information provided in TM shall allow the correlation of on board time with UTC with the accuracy provided by the CDMS	AD4 Sect. 2.1.4 TIM-2

OBS testing and maintenance requirements

Req. ID	Description	Reference
OBS-CUR-SM1	Entering the instruments Test Mode shall not require disabling of fault management (autonomy) functions	AD4 Sect. 2.2.4 INFT-3
OBS-CUR-SM2	The OBS shall be able to perform regular HW self checks (voltages and temperature), and SW checks when the OBS is started (checksum of PM and EEPROM content)	AD4 Sect 2.2.1 AUT-10
OBS-CUR-SM3	An OBS software verification facility (for EEPROM, RAM code) shall be provided on board	NTBT
OBS-CUR-SM4	The OBS shall reside in non volatile memories: PROM and EEPROM	AD4 Sect. 3.6 OBSM-1
OBS-CUR-SM5	Functionally distinct memory areas shall be assigned on board to the following categories: – programme code; – fixed data; – variables and parameters	AD2 Sect. 5.13.2 AD4 Sect.3.5 MM-1
OBS-CUR-SM6	It shall be possible to load, dump and check with a single TC the contents of a memory area: the OBS shall be able to read from, write to and checksum areas of, the DPU memory blocks	AD4 Sect. 3.5 MM-2, MM-3, MM-7, MM-8, MM-9, MM-10, MM-11
OBS-CUR-SM7	The OBS shall be able to detect data corruptions in the DPU memory after a memory load command	AD4 Sect. 3.5 MM-5, MM-6 AD6 Sect. 4.8
OBS-CUR-SM8	The OBS shall be able to provide an answer to an “are you alive” request originating from the CDMS for testing the end-to-end connection between ground and the DPU	AD4 Sect. 3.14 FTS-1, FTS-2, FTS-3

Autonomy functions requirements

Req. ID	Description	Reference
OBS-CUR-AF1	The OBS shall be able to implement pre defined procedures (health autonomy functions) on detection of DPU and other instrument subsystems anomalies, without any ground intervention	AD3 AD4 Sect. 2.1.1 CTRL-1 AD4 Sect. 2.2.1 AUT-9 AD6 Sect. 4.6
OBS-CUR-AF2	The OBS shall be able to generate and to transmit (in event packets) reports of failures and/or anomalies detected on board, indicating the level of criticality	AD4 Sect. 2.2.1 AUT-11 AD4 Sect. 3.4.3 EVRP-1

Req. ID	Autonomy Functions requirements (ctd)	Reference
OBS-CUR-AF3	The OBS shall be able to transmit (in event packets) reports of the adopted autonomy on board actions. It shall provide all the support information necessary for the ground analysis in case of failure/anomaly detection, including the indication of the anomaly time of occurrence	AD4 Sect. 2.2.1 AUT-11, AUT-12, AUT-15 AD4 Sect. 3.4.3 EVRP-3
OBS-CUR-AF4	The OBS shall be able to echo all the relevant inputs actually used during the execution of the autonomy functions. This is to allow a full check of the correctness of the executed actions	AD4 Sect. 2.1.3 TM-8 AD4 Sect. 3.4.3 EVRP-4
OBS-CUR-AF5	The OBS shall provide all the event packets with a counter which permits the unambiguous identification of missing packets	AD4 Sect. 2.1.3 TM-18
OBS-CUR-AF6	There shall be a minimum period before the next event packet reporting the same event (e.g. a transition to out-of-limits) can be issued. For the current OBS version this minimum period is set to the nominal HK rate	AD4 Sect. 3.4.3 EVRP-5
OBS-CUR-AF7	The OBS shall be able to enable/disable on request (via a dedicated TC) each individual autonomy function	AD4 Sect. 2.2.1 AUT-15
OBS-CUR-AF8	All parameters used for autonomy fault management shall be updateable by TC and available in the event packets	AD4 Sect. 2.2.1 AUT-19
OBS-CUR-AF9	For long execution processes, the OBS shall report in the output TM the start and the end of the process	AD4 Sect. 3.4.3 EVRP-8
OBS-CUR-AF10	The knowledge of the actual health status of all the HW unit shall be available to the spacecraft through the HK packet	AD4 Sect. 2.2.1 AUT-22
OBS-CUR-AF11	The OBS shall implement a command to execute the warm reset of the DPU	NTBT

3.1.2 Constraint requirements

Telemetry rate requirements

Req. ID	Description	Reference
OBS-CUR-TR1	The OBS shall be able to support a total output TM rate of 130 kbps averaged on 24 hours	AD3
OBS-CUR-TR2	The OBS shall be able to support a burst mode of 300 kbps for 30 minutes in 24 hours for the output TM data rate	AD3
OBS-CUR-TR3	The OBS shall not occupy more space in PM than supported by EEPROM size	NTBT

3.2 PACS

As far as the OBS is concerned, PACS can be divided into three sub-units: the DPU, the SPU, which compresses the scientific data, and the DEC/MEC, which drives and reads the detectors (photoconductors and bolometers) and controls the mechanical parts. The SPU can be in turn divided in two components: a low level SPU, which handles the initialisation of the unit, and a high level SPU, which processes the scientific data. The context diagram for PACS OBS is shown in Figure 3-1.

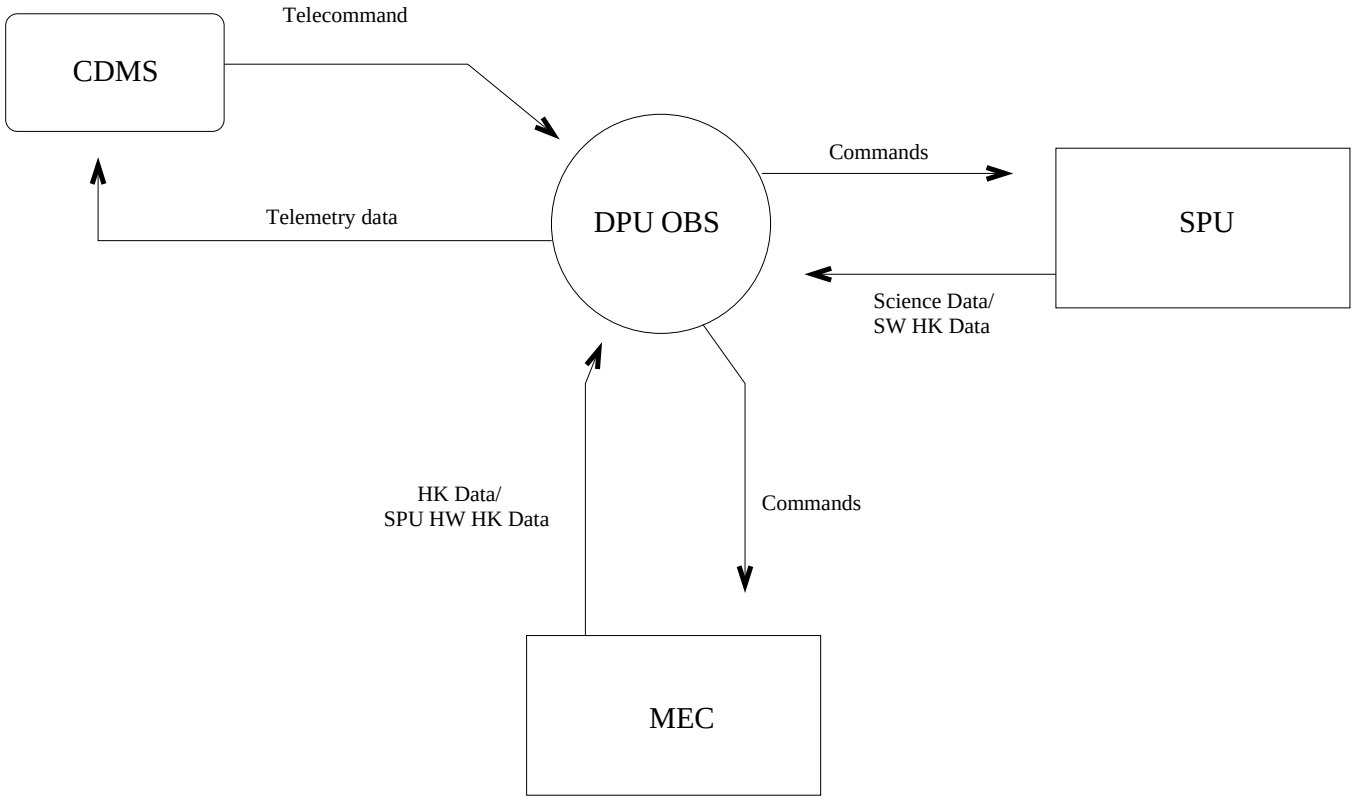

Figure 3-1: *PACS DPU On Board Software Context Diagram.*

The DPU is linked to the others subsystems through one IEEE-1355-1995-DS-DE serial interface, set to a transfer rate of 10Mbps, which can handle three links. One link is dedicated to the bi-directional communications with DEC/MEC, while the SPU, which contains two DSP 21020, one for each wavelength channel, is connected to the DPU through the remaining two links of the interface. The lines drawn in Figure 3-1 show the data flows and not the physical interface between the subunits.

Depending on the specific operational mode, the SPU SW compression parameters will be set by DPU according to pre-defined tables stored on board, and routed to the SPU through the DEC/MEC.

3.2.1 PACS Capability Requirements

The bit rates for the communications with CDMS are those reported in AD3. The communications with the subsystems are detailed in the ICDs.

General requirements

Req. ID	Description	Reference
OBS-PUR-GE1	The OBS shall support all the operative modes given in AD3: Primary Photometer, Primary Spectrometer, Parallel, Standby, Recycle, Safe, Init, Off, Test, Non Prime	AD3 Section 4.6
OBS-PUR-GE2	The OBS shall support all the instrument observing modes described in AD7: Two-band Photometry, Single-band Photometry, Line Spectroscopy, Range Spectroscopy	AD7
OBS-PUR-GE3	The OBS shall be able to exchange memory contents with the subsystems	AD3
	Interface with SPU subsystem	
OBS-PUR-GE4	The DPU shall provide to the SPU, through DEC/MEC, the compression parameters specific to each observing mode. These parameters will be read in the onboard tables and will be not the result of a DPU onboard computation	UVIE
OBS-PUR-GE5	The OBS shall ensure that the scientific data produced by the two wavelength channels are not mixed during the packetisation process	NTBT

A Matrix of compliance

In this section, the whole set of requirements is reported. For each requirement the column Testing gives the verification method (T means that the requirement is to be tested with a specific procedure, D means that the requirement is tested with design review).

(see Note) means that a note, not reported here, follows the requirement; see the text in the previous sections to read the note.

A.1 Capability requirements

Switch-on requirements

Req. ID	Description	Testing
OBS-CUR-ON1	The DPU shall support the switch-on procedure described in AD9	D

Switch-off requirements

Req. ID	Description	Testing
OBS-CUR-OF1	The DPU shall support the switch-off procedure as described in AD7	D

Telecommands requirements

Req. ID	Description	Testing
OBS-CUR-TC1	The OBS shall be able to handle the following types of commands: a) send a measurament instruction to the other subsystems; b) execute a function/sequence in the DPU; c) execute an OBCP in the DPU The list of commands implemented by the DPU is reported in RD8	T
OBS-CUR-TC2	The OBS shall be able to: a) update/add a SW function; b) update/add a procedure	T
OBS-CUR-TC3	The OBS shall accept all the instrument commands originated from the CDMS. The commands are issued as TC packets structured following the definition reported in AD5 **(see Note)**	T
OBS-CUR-TC4	The OBS shall receive, unpack and process all the uplinked TC packets at the maximum command data rate (2 TC per second, AD2 Sect. 5.11.4, during nominal operations), regardless of packet sizes. For test purposes the TC data rates could be higher **(see Note)**	T

Req. ID	TCs requirements (ctd)	Testing
OBS-CUR-TC5	The OBS shall acknowledge, using TM report packets, the receipt of the TCs. A specific field in the acknowledgement area (header) will indicate what type of acknowledgement (if any) is needed for each TC	T
OBS-CUR-TC6	The OBS shall avoid that the reception, processing and execution of TCs affects any other independent on board process, unless the received TC is an immediate command (e.g. Abort)	T
OBS-CUR-TC7	The OBS shall be able to check the conformity of the received packets according to the standard given in AD5, to check their integrity and to reject non-valid packets	T
OBS-CUR-TC8	The OBS shall reject non-valid packets at the earliest possible stage in the on board acceptance and execution process. The related ICSs shall not be executed at all	D
OBS-CUR-TC9	The OBS shall generate a report indicating the result of the acceptance of the received TC packet. In case of non valid packets, this report shall include the reason for not acceptance	T
OBS-CUR-TC10	The OBS shall generate the TC verification report at the earliest possible stage in the on board acceptance and execution process	D
OBS-CUR-TC11	The OBS shall transmit the commands to the relevant subsystems of the instruments	T
OBS-CUR-TC12	The OBS shall be able to generate, on request, a progress report or anomaly report reflecting the completion status (success or failure) of the stages of the TC execution process **(see Note)**	T
OBS-CUR-TC13	The OBS shall generate a TM packet for unsuccessful command execution	T
OBS-CUR-TC14	The OBS shall be able to abort the execution of an OBCP whenever a special control TC is received	T
OBS-CUR-TC15	The OBS shall support the possibility of updating, via dedicated TCs, all the parameters tables stored on board	T
OBS-CUR-TC16	The OBS shall interrupt, if requested, the transmission of TM packets to the CDMS **(see Note)**	T

TM generation requirements

Req. ID	Description	Testing
OBS-CUR-TM1	The OBS shall pack all the packets according to the ESA TM standards	T
OBS-CUR-TM2	The OBS shall be able to acquire the science data provided by the other subsystems and to transmit them to the CDMS following the protocol defined in AD5 Appendix 9	T

Req. ID	TM Generation requirements (ctd)	Testing
OBS-CUR-TM3	The OBS shall be able to collect the HK data provided by the other subsystems and by the DPU itself during all nominal modes of the instrument, including any instrument SAFE mode. This requirement does not apply in specific non-nominal mode (as processor halted/reset)	T
OBS-CUR-TM4	The OBS shall be able to analyse the collected HK parameters according to operating mode and limit check criteria	D
OBS-CUR-TM5	The OBS shall packetise the collected HK parameters into dedicated output TM packets. A nominal HK TM packet will be defined for each instrument mode, containing all the relevant parameters. The structure of this predefined TM packet shall be available on board	T
OBS-CUR-TM6	The TM packets shall report the APID according to AD5	D
OBS-CUR-TM7	In different modes of the instruments, some of the parameters to be reported into the nominal HK packet will not be valid. The OBS shall be able to clearly indicate in the packet which are the valid parameters **(see Note)**	T
OBS-CUR-TM8	The OBS shall be able to provide the nominal HK TM packet (with a pre-defined content) at a normal reporting rate of 0.5 Hz	T
OBS-CUR-TM9	The OBS shall be able to modify, accordingly to dedicated TCs, the pre-defined sets of HK parameters to be included into the HK/diagnostic TM packet **(see Note)**	T
OBS-CUR-TM10	The OBS shall be able to include in the TM packets used to monitor the SW status all the commandable parameters used by the executed OBCP	T
OBS-CUR-TM11	The OBS shall provide only actual values of the HK parameters and not changes (or delta values) since the last readout: the *filtered* reporting mode is not allowed (the DPU will assume that the values sent by the other subsystems are actual values and not delta values)	D
OBS-CUR-TM12	The OBS shall be able to generate additional types of HK TM packets related to specific operational modes or configurations	T
OBS-CUR-TM13	The DPU shall transmit the request of generating additional HK packets containing oversampled data to DEC/MEC which is in charge to sample the values with the specified frequency. The DPU will generate the TM packet without checking that the DEC/MEC actually sampled the parameter(s) with the correct frequency	T

Req. ID	TM Generation requirements (ctd)	Testing
OBS-CUR-TM14	The OBS shall produce science data packets which will contain sufficient information to allow the data processing without the necessity to refer to HK TM to derive subsystems parameters. The set of subsystem parameters is sent to the DPU by the SPU. The DPU transmits it to the CDMS without any processing	T
OBS-CUR-TM15	The OBS shall be able to provide a time info in the header of all output TM packets. The meaning of this time info depends on the specific service type/subtype	D
OBS-CUR-TM16	All science, nominal HK and event packets shall report information identifying to which observation they belong	T
OBS-CUR-TM17	The OBS shall be able to buffer TM packets until they are requested by the CDMS. The dimension of the buffer is 400 packets for science, 64 for HK and 32 for events. In case a science buffer overlow occurs, the OBS shall ensure that the CDMS will be informed through a specific event packet	T

Synchronization requirements

Req. ID	Description	Testing
OBS-CUR-SY1	The OBS shall be able to synchronise and to verify the DPU internal clock with the CDMS master clock	T
OBS-CUR-SY2	The OBS shall flag, after switch on or reset, each packet (in the header time field) whenever the time has not yet been synchronised	T
OBS-CUR-SY3	Timing information provided in TM shall allow the correlation of on board time with UTC with the accuracy provided by the CDMS	T

OBS testing and maintenance requirements

Req. ID	Description	Testing
OBS-CUR-SM1	Entering the instruments Test Mode shall not require disabling of fault management (autonomy) functions	D
OBS-CUR-SM2	The OBS shall be able to perform regular HW self checks (voltages and temperature), and SW checks when the OBS is started (checksum of PM and EEPROM content)	T
OBS-CUR-SM3	An OBS software verification facility (for EEPROM, RAM code) shall be provided on board	T
OBS-CUR-SM4	The OBS shall reside in non volatile memories: PROM and EEPROM	D

Req. ID	OBS testing and maintenance requirements (ctd)	Testing
OBS-CUR-SM5	Functionally distinct memory areas shall be assigned on board to the following categories: – programme code; – fixed data; – variables and parameters	D
OBS-CUR-SM6	It shall be possible to load, dump and check with a single TC the contents of a memory area: the OBS shall be able to read from, write to and checksum areas of, the DPU memory blocks	T
OBS-CUR-SM7	The OBS shall be able to detect data corruptions in the DPU memory after a memory load command	T
OBS-CUR-SM8	The OBS shall be able to provide an answer to an “are you alive” request originating from the CDMS for testing the end-to-end connection between ground and the DPU	T

Autonomy functions requirements

Req. ID	Description	Testing
OBS-CUR-AF1	The OBS shall be able to implement pre defined procedures (health autonomy functions) on detection of DPU and other instrument subsystems anomalies, without any ground intervention	D
OBS-CUR-AF2	The OBS shall be able to generate and to transmit (in event packets) reports of failures and/or anomalies detected on board, indicating the level of criticality	T
OBS-CUR-AF3	The OBS shall be able to transmit (in event packets) reports of the adopted autonomy on board actions. It shall provide all the support information necessary for the ground analysis in case of failure/anomaly detection, including the indication of the anomaly time of occurrence	T
OBS-CUR-AF4	The OBS shall be able to echo all the relevant inputs actually used during the execution of the autonomy functions. This is to allow a full check of the correctness of the executed actions	T
OBS-CUR-AF5	The OBS shall provide all the event packets with a counter which permits the unambiguous identification of missing packets	D
OBS-CUR-AF6	There shall be a minimum period before the next event packet reporting the same event (e.g. a transition to out-of-limits) can be issued. For the current OBS version this minimum period is set to the nominal HK rate	D
OBS-CUR-AF7	The OBS shall be able to enable/disable on request (via a dedicated TC) each individual autonomy function	T

Req. ID	Autonomy Functions requirements (ctd)	Testing
OBS-CUR-AF8	All parameters used for autonomy fault management shall be updateable by TC and available in the event packets	T
OBS-CUR-AF9	For long execution processes, the OBS shall report in the output TM the start and the end of the process	T
OBS-CUR-AF10	The knowledge of the actual health status of all the HW unit shall be available to the spacecraft through the HK packet	D
OBS-CUR-AF11	The OBS shall implement a command to execute the warm reset of the DPU	T

A.2 Constraint requirements

Telemetry rate requirements

Req. ID	Description	Testing
OBS-CUR-TR1	The OBS shall be able to support a total output TM rate of 130 kbps averaged on 24 hours	T
OBS-CUR-TR2	The OBS shall be able to support a burst mode of 300 kbps for 30 minutes in 24 hours for the output TM data rate	T
OBS-CUR-TR3	The OBS shall not occupy more space in PM than supported by EEPROM size	D

A.3 PACS Capability requirements

General requirements

Req. ID	Description	Testing
OBS-PUR-GE1	The OBS shall support all the operative modes given in AD3: Primary Photometer, Primary Spectrometer, Parallel, Standby, Recycle, Safe, Init, Off, Test, Non Prime	D
OBS-PUR-GE2	The OBS shall support all the instrument observing modes described in AD7: Two-band Photometry, Single-band Photometry, Line Spectroscopy, Range Spectroscopy	D
OBS-PUR-GE3	The OBS shall be able to exchange memory contents with the subsystems	T
	Interface with SPU subsystem	
OBS-PUR-GE4	The DPU shall provide to the SPU, through DEC/MEC, the compression parameters specific to each observing mode. These parameters will be read in the onboard tables and will be not the result of a DPU onboard computation	D
OBS-PUR-GE5	The OBS shall ensure that the scientific data produced by the two wavelength channels are not mixed during the packetisation process	D