FIRST

DPU/ICU On Board Software

User Requirements Document

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Prepared by: Anna Maria Di Giorgio
Milena Benedettini
Claudio Codella
Stefano Pezzuto

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Checked by: Riccardo Cerulli-Irelli
Approved by: Renato Orfei

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Draft 1		29/11/1999	Merged the three URD in only one document by IFSI
Draft 2		31/03/2000	Inserted comments from the three consortia
Draft 3.1		13/06/2000	SPIRE section updated. Common section updated in accordance with the new versions of the applicable documents.
Draft 3.2		30/06/2000	PACS section updated.
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1 Introduction

The astronomical satellite FIRST will host onboard three instruments: HIFI, PACS and SPIRE. The instruments are completely different from each other in many respects, from the optical design to their scientific goals. However some commonalities among them have been identified in order to ease the realisation of the satellite: one of the deepest commonality regards the units responsible for the interface between the spacecraft and each instrument. One only institute (IFSI) is in charge of providing these units, taking care of both the hardware and the software realisation.

This document contains the User Requirements on the DPU/ICU[1] On Board Software. It exploits the needs common to all the three instruments to the maximum possible extent. Requirements specific to each instrument are collected at the end of the document in three separate subsections. IFSI is responsible to ensure that the three consortia will always be given the same document.

Each instrument can be broken down in sub-units called subsystems. The number and the tasks of each subsystem are described in the appropriate subsection, but it is necessary to anticipate already in this introduction that PACS has CPU controlled subsystems, with their own 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.

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 FIRST satellite.

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 Subsystem
CNR	Consiglio Nazionale delle Ricerche
CPU	Control Processing Unit

[1] The most difficult problem to solve in assessing this commonality has been the choice of the name for these units. And in fact no solution at all has been found: PACS and SPIRE adopted DPU (Digital Processing Unit), while HIFI preferred ICU (Instrument Control Unit). The notation DPU/ICU will be then used throughout this document.

CSL	Centre Spatial de Liège
DPU	Digital Processing Unit
DRCU	Detector Readout and Control Unit
EEPROM	Electrically Erasable Programmable Read Only Memory
FCU	FPU Control Unit
FIRST	Far InfraRed and Submillimeter Telescope
FOV	Field Of View
FPU	Focal Plane Unit
FTS	Fourier Transform Spectrometer
HEMT	High Electron Mobility Transistor
HIFI	Heterodyne Instrument for FIRST
HK	HouseKeeping
HRS	High Resolution Spectrometer
HS	High Speed
HW	HardWare
ICC	Instrument Control Centre
ICS	Instrument Command Sequence
ICU	Instrument Control Unit
IF	Intermediate Frequency
IFSI	Istituto di Fisica dello Spazio Interplanetario
LCU	Local oscillator Control Unit
LO	Local Oscillator
LOU	Local Oscillator Unit
LSU	Local oscillator Synthesiser Unit
MEC	Mechanical Control unit
MOC	Mission Operations Centre
OBS	On Board Software
OIRD	Operations Interface Requirements Document
PACS	Photoconductor Array Camera and Spectrometer
PCS	Permanent Command Sequence
PROM	Programmable Read Only Memory
RAM	Random Access Memory
ROM	Read Only Memory
SPIRE	Spectral and Photometric Imaging Receiver
SPU	Signal Processing Unit
SRON	Space Research Organization Netherlands
SW	SoftWare
TAI	Temps Atomique International
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
TC	TeleCommand
TM	TeleMetry
UART	Universal Asynchronous Receiver Transmitter
UR	User Requirement
URD	UR Document
UVIE	University of Vienna
WBS	Wide Band Spectrometer
WE	Warm Electronics

1.2.2 Abbreviations

ID Identification

1.3 References

1.3.1 Applicable Documents

Document Reference	Name	Number/version/date
AD1	FIRST/Planck Instrument Interface Document Part A	PT-IIDA-04624 Draft 0-3, 15 May 2000
AD2-H	FIRST/Planck Instrument Interface Document Part B Instrument "HIFI"	PT-HIFI-02125, Issue 1/0, 1 September 2000
AD2-P	FIRST/Planck Instrument Interface Document Part B Instrument "PACS"	PT-PACS-02126, Draft 0-4 10 May 2000
AD2-S	FIRST/Planck Instrument Interface Document Part B Instrument "SPIRE"	SCI-PT-IIDB/SPIRE-02124 Issue 1.0 01 Sep 2000
AD3	FIRST/PLANCK Operations Interface Requirements Document	SCI-PT-RS-07360 Draft 5 03 May 2000
AD4	FIRST/PLANCK Packet Structure Interface Control Document	SCI-PT-IF-07527 Draft 0 22 February 2000
AD5	FIRST Instrument Commanding Concepts	Draft 1, 22 October 1999
AD6	Operating modes of the PACS Instrument.	PACS-ME-PL-005 7 December 1999
AD7	Operating Modes for the SPIRE Instruments	SPIRE-RAL-DOC-000320 Draft 0.22, 14 June 2000
AD8	SPIRE Instrument Requirements document	SPIRE/RAL/N/0034 Issue 0.31 25 May 2000
AD9	FIRST HIFI ICU Subsystem Specification	Draft 1, 29 May 2000
AD10	FIRST SPIRE Electrical Interface Control Document	SAp-SPIRE-Cca-24-00 Issue 0.2, 21 June 2000
AD11	HIFI Interface Control Document	SRON-G/HIFI/SP/1999-001 Issue 2a, 28 June 2000

1.3.2 Reference Documents

Document Reference	Name	Number/version
RD1	Guide to applying the ESA software engineering standards to small software projects	BSSC(96)2, Issue1, May 1996
RD2	FIRST SPIRE DPU subsystem specification document	Draft 2 – 13/06/2000
RD3	FIRST SPIRE DPU-DRCU Interfaces	SP-RCI-5.7.00 Issue 1 05/07/2000
RD4	Telemetry and Telecommand Packet Utilisation Standard	ECSS-E-70/41 Draft 04 April 1999

RD5	DPU to DEC/MEC interface description.	PACS-CL-TN-003 15 March 2000
RD6	SPU requirements specification	PACS-IAC-SP-001. 24 September 1999
RD7	SPU OBS URD	PACS-TW-SR-001 11 April 2000
RD8	PROM Software URD	PACS-IC-RS-001.01.A 3 May 2000
RD9	DEC/MEC Software URD	PACS-CL-SP-001 17 February 2000

1.4 Overview of the document

The DPU/ICU 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: first, the requirements common to all the three instruments are reported; then three subsections describe the requirements specific to each instrument.

2 General Description

2.1 General capabilities

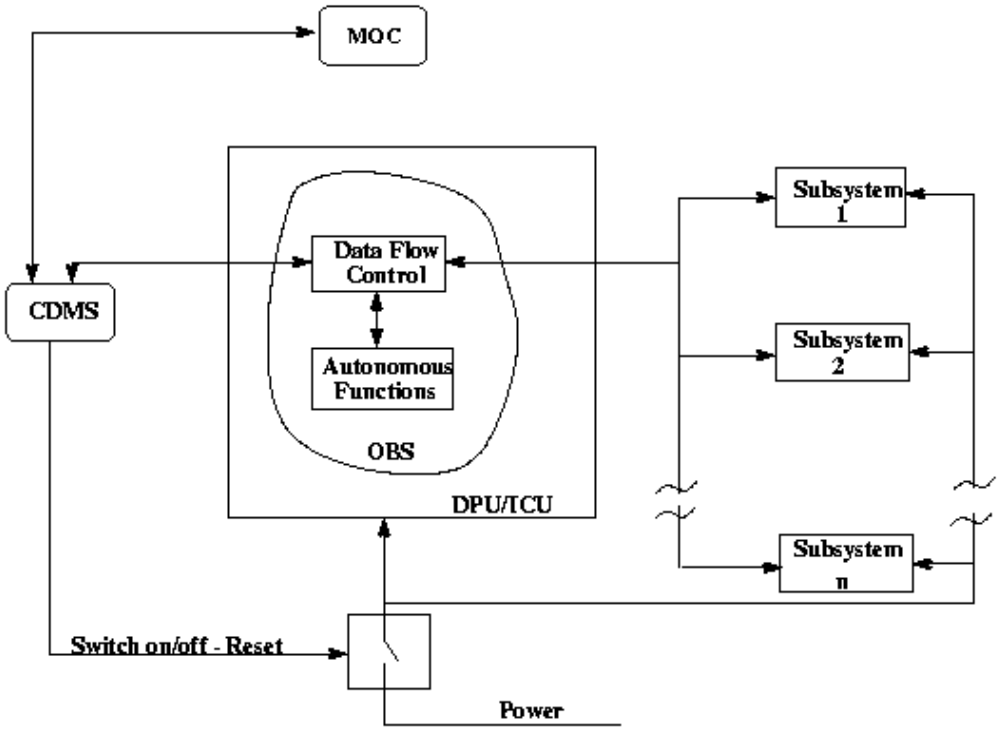

Figure 2-1 *High level functionality of DPU/ICU OBS: dialogue with subsystems and check of health status of the instrument (autonomous functions). On the basis of the HK parameters values DPU/ICU can ask CDMS to switch off part or the whole instrument. To simplify the figure only one power line has been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

Figure 2-1 gives an overview of the activities of OBS. The DPU/ICU is the only data interface of the instruments with the satellite, so the main capabilities of OBS will be related with TCs and TM handling. In particular, TCs packets will be received, interpreted according to their priority, translated into the instrument ICS and, when relevant, the appropriate command instructions are sent to the subsystems. The DPU/ICU will then receive the science data and all the HK data (in the case of HIFI, the LCU, LSU and FCU subsystems will send their HK data only on request), 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 autonomous functions in order to prevent any damage to the instrument. Depending on the severity of the detected anomaly, the measurement could even be reset and/or DPU/ICU could ask CDMS to set an instrument to stand by mode and/or to switch off an instrument or some of its subsystems.

STYLEREFSEQARABICREFMERGEFORMATTM will be structured in four types of packets: science, HK, event and TC verification. 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 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 the corresponding IID-B (AD2-H, AD2-P and AD2-S); for SPIRE they are detailed in AD7, for PACS in AD6.

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 (AD1 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 autonomously. In particular, the instrument will need on board monitoring and autonomous features to recover from non nominal situations: this might require to request CDMS to switch off parts or the whole instrument. It is decided that while an autonomous 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 1MHz.
    5. Nominal bit rate is 100 kbps, averaged on 24 hours, including HK, events and TC verification (TBC);
    6. Burst mode bit rate is 350kbps (400kbps for PACS) (TBC);
    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
    - Program RAM = 3 MB
    - Data RAM = 2 MB
  - Clock speed ≅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 the 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/ICU 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 serial interfaces described in the instrument specific subsections. The microprocessor for DPU/ICU is Analog Devices 21020, developed for space applications by TEMIC.

The OBS will be developed in the following environment:

- Virtuoso [2] as operating system.
- AxiomSys [3] as structured analysis based CASE tool.
- SIGMA[4] 33MHz ADSP 21020 development board for SW testing.

3 Specific Requirements

The main functions of the OBS are:

- Acceptance of instrument commands from CDMS;
- Execution of predefined commanding sequences;
- 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 and/or activate subsystem redundancy when an anomaly occurs.
- Science data acquisition (not applicable to PACS) and packetisation;
- HK data packetisation (and acquisition, in the case of HIFI);
- Transmission of data (science, HK, events and TC verification) 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 (patches, tables, command sequences, TBC);
- Self test and SW verification facilities;
- Possibility to load and dump part of DPU/ICU memory;
- Possibility to write and check EEPROM: possibility to inhibit these functions during flight operations.

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

[2] Virtuoso is a trademark of Eonic Systems nv.
[3] AxiomSys is a trademark of Structured Technology Group, Inc.
[4] Sigma board is manufactured by BittWare research systems

generation, synchronisation, SW testing and maintenance, autonomous functions and TM rate. The requirements common to all the three instruments are listed in section 3.1; three separate subsections (3.2.1, 3.2.2, 3.2.3) contain the requirements specific to each instrument.

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 substituted for C (requirements common to all the three instruments), H (HIFI), P (PACS) or S (SPIRE) specific requirements. 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
OF switch off requirements
TC TCs requirements
TM TM generation requirements
SY synchronization requirements
SM OBS testing and maintenance requirements
AF autonomous functions requirements
TR TM rate requirements

requirements specific to HIFI
GE general
SM subsystems monitoring

requirements specific to PACS
GE general

requirements specific to SPIRE
FU functional
TM telemetry
GE general

3.1.1 Capability requirements

Req. ID	Description	Reference
	SWITCH-ON REQUIREMENTS	
OBS-CUR-ON01	The DPU/ICU memory shall be checked as first task after switch on of the instrument. The sequence shall be: 1) check the content of non-volatile memory (EEPROM test first, then PROM test), through checksum; 2) check the volatile memory, through	IFSI

	simple writing/reading operations.	
OBS-CUR-ON02	The health of the DPU/ICU subsystem shall be checked by comparing a TBD list of HK parameters with pre-defined values.	IFSI
OBS-CUR-ON03	An event report shall be generated reporting the results of the three checks performed (see OBS-CUR-ON01, OBS-CUR-ON02). In case of any failure this report shall clearly state which test failed and why.	IFSI
OBS-CUR-ON04	The event report (see OBS-CUR-ON04) shall be generated after no more than TBD seconds, otherwise the CDMS shall assume that the DPU/ICU did not properly boot.	IFSI
OBS-CUR-ON05	After receiving the specific packet from CDMS informing that a subsystem has been switched on the DPU/ICU shall wait TBD seconds for HK parameters from that subsystem and shall compare their values with a pre-defined list. An event report shall be generated stating whether the subsystem actually provided this list and whether the reported values are inside nominal ranges. **Note** (from IFSI): *it is likely that the waiting time will not be the same for all the subsystems.*	IFSI
	SWITCH-OFF REQUIREMENTS	
OBS-CUR-OF01	After receiving the specific packet from CDMS informing that a subsystem is going to be switched off the DPU/ICU shall check the status of that subsystem through a TBD list of HK parameters. The result of this check will be included in an event report.	IFSI
OBS-CUR-OF02	After receiving the specific packet from CDMS informing that the DPU/ICU is going to be switched off the DPU/ICU shall check its status through a TBD list of HK parameters.	IFSI
	TELECOMMANDS REQUIREMENTS	
OBS-CUR-TC01	The OBS shall be able to handle the following types of commands: a) Send a measurement instruction to the other subsystems; b) Execute a function in the DPU/ICU; c) Interpret a procedure in the DPU/ICU.	AD5 AD8 IRD-CMD-R09
OBS-CUR-TC02	The OBS shall be able to: a) Update/add a SW function; b) Update/add a procedure.	AD5 Sect. 3.2.2 AD8 IRD-CMD-R13
OBS-CUR-TC03	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 the FIRST/Planck Packet Structure Interface Control Document (AD4) according to ESA standards via a TBW protocol to adapt AD4 to MIL-STD-1553B (AD4 Appendix 9).	AD3 Sect. 1.5.1 AD4 Appendix 9 AD8 IRD-DATA-R01

OBS-CUR-TC04	The OBS shall receive, unpack and process all the uplinked TC packets at the maximum command data rate (2 TC per second, AD1 section 5.11.4), regardless of packet sizes. **Note**: *note that processing the TC packets does not imply executing the command.*	AD3 Sect. 2.1.1 CTRL5, CTRL-6 AD8 IRD-CMD-R01
OBS-CUR-TC05	The OBS shall acknowledge, using TM event 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. The acknowledge acceptance is mandatory.	AD3 Sect. 3.2 TCV-0 AD4 Sect. 3.1.2.1
OBS-CUR-TC06	The OBS shall immediately (in TBD μs) execute the TCs.	AD5 Sect. 4.1
OBS-CUR-TC07	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)	AD3 Sect. 2.1.2 TC-8 AD8 IRD-CMD-R10
OBS-CUR-TC08	The OBS shall be able to check the conformity of the received packets to the FIRST/PLANCK Packet Structure Interface Control Document (AD4) standard, to check their integrity and to reject non-valid packets.	AD5 Sect. 4.3 AD4 Sect. 3.1.2.1 AD3 Sect. 3.1 PACK 14 AD8 IRD-CMD-R02
OBS-CUR-TC09	The OBS shall be able to check the validity of APIDs, whose structure is defined in AD4.	AD3 Sect. 3.1 PACK 14 AD4 Sect. 3.1.1.1, Appendix 3
OBS-CUR-TC10	The OBS shall reject non-valid packets at the earliest possible stage in the on board acceptance and execution process. The related command sequence shall not be executed at all.	AD3 Sect. 2.1.2 TC7 AD5 Sect. 4.3 AD8 IRD-CMD-R02
OBS-CUR-TC11	The OBS shall generate a report indicating the result of the verification of the conformity to AD4 standards of the received TC packet. In case of non valid packets, this report shall include the reason for not acceptance.	AD3 Sect. 3.2 TCV-1, TCV-2 AD8 IRD-CMD-R04
OBS-CUR-TC12	The OBS shall generate the TC verification report within TBD sec from the reception of the TC.	AD3 Sect. 3.2 TCV-7 AD8 IRD-CMD-R04
OBS-CUR-TC13	The OBS shall generate a report indicating the result of the verification done to check if the received TCs have illegal or inconsistent Application Data (AD4 Sect. 5.1.2.1, Telecommand Acceptance Report-Failure, Code 5).	AD3 Sect. 3.2 TCV-2 AD4 Sect. 3.1.2.1, Sect. 5.1.2.1 AD5 Sect. 4.3 AD8 IRD-CMD-R04
OBS-CUR-TC14	The OBS shall transmit the commands to the relevant subsystems of the instruments.	AD2-H,-P,-S
OBS-CUR-TC15	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.	AD3 Sect. 3.2 TCV-3 AD8 IRD-CMD-R03 IRD-CMD-R04
OBS-CUR-TC16	The OBS shall generate a TM event packet for unsuccessful command execution.	AD3 Sect. 3.2 TCV-4 AD8 IRD-CMD-R04
OBS-CUR-TC17	The OBS shall pack the event reports according to the	AD5 Sect. 4.3

	ESA packet telemetry standards reported in AD4 (via a TBW protocol to adapt AD4 to MIL-STD-1553B, AD4 Appendix 9).	
OBS-CUR-TC18	The OBS shall be able to abort the current command execution whenever a special control TC is received.	AD5 Sect. 4.1 AD8 IRD-CMD-R10
OBS-CUR-TC19	The OBS shall support the possibility of updating, via dedicated TCs, all the parameters tables stored on board.	AD3 Sect. 3.2 TC-9 AD8 IRD-CMD-R12
OBS-CUR-TC20	The OBS shall interrupt, if requested by CDMS, the transmission to CDMS of TC verification packets.	AD3 sect 3.2 TCV-5
OBS-CUR-TC21	The OBS shall identify lost commands (by a jump in the TC packet counter) and report this in an event packet.	SPIRE
OBS-CUR-TC22	The OBS shall be able to measure and store a pointing correction, by executing a peak-up procedure. **Note***: For PACS the peak-up procedure will be executed by both DPU and SPU.*	AD2-H Sect. 5.12.2 AD2-P Sect. TBD AD2-S Sect. 5.12.1
	TM GENERATION REQUIREMENTS	
OBS-CUR-TM01	The OBS shall be able to acquire the science data provided by the other subsystems, to packetise them accordingly to AD4 and to transmit them to CDMS following the protocol defined in AD4 Appendix 9.	IFSI AD8 Sect. TBD
OBS-CUR-TM02	The OBS shall be able to collect the HK data provided by the other subsystems and by the DPU/ICU itself during all nominal modes of the instrument, including any instrument SAFE mode.	AD3 Sect. 2.1.1 CTRL-4 AD8 IRD-TLM-R05 AD8 Sect. TBD
OBS-CUR-TM03	The OBS shall be able to analyse the collected HK parameters according to operating mode and limit check criteria.	AD3 Sect. 2.1.1 CTRL-4 AD8 Sect. TBD
OBS-CUR-TM04	The OBS shall packetise the collected HK parameters into dedicated output TM. A nominal HK TM packet will be defined, containing all (TBD) instrument parameters. The structure of this predefined TM packet shall be available on board.	AD3 Sect. 3.2 TCV-9 AD3 Sect. 3.4.1 PERP6, AD5 Sect. 4.5.1
OBS-CUR-TM05	The OBS shall be able to format packets of the instrument HK data according to ESA standard (reported in AD4) and to transmit them to CDMS via a TBW protocol to implement the MIL-STD-1553B (AD4 Appendix 9).	AD5 Sect. 4.5
OBS-CUR-TM06	The TM packets shall report the same APID as used in the parent TC, in order to uniquely identify the onboard source of the packet.	AD3 Sect. 3.1 PACK-2 AD4 Sect. 4.1.1.1, Appendix 3
OBS-CUR-TM07	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.	AD5 Sect. 4.5.1 AD3 Sect. 3.1 PACK-3
OBS-CUR-TM08	The OBS shall be able to provide the nominal HK TM packet (with a pre-defined content) at a normal reporting rate of 1 Hz.	AD3 Sect. 3.4.1 PERP-6 (AD3 Sect. 3.1 PACK-9 see note)

	Note (from IFSI)*: It should be checked that this requirement is not in contrast with AD3-PACK-9 "TM parameters shall be sampled at a frequency ensuring that no information of operational significance, for all nominal and contingency operation, is lost*".	AD5 Sect. 4.5.1
OBS-CUR-TM09	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.	AD3 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 functions/ procedures.	AD3 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. **Note** (from IFSI applicable to PACS)*: the DPU will assume that the values sent by other subsystems are actual values and not delta values*.	AD3 Sect. 2.1.3 TM-11
OBS-CUR-TM12	The OBS shall be able to provide on request (via a dedicated TC) a specified HK packet, additional to the default HK TM.	AD3 Sect. 3.4.1 PERP-7
OBS-CUR-TM13	The OBS shall be able to generate up to TBC additional types of standard HK TM packets.	AD8 Sect. TBD AD8 IRD-TLM-R06
OBS-CUR-TM14	For diagnostic purposes, it will be possible to generate additional HK packets containing oversampled data. The maximum sampling rate will be TBD samples per second (being the minimum sampling interval consistent with the measurement of the transient phenomena to be monitored). **Note** (from IFSI applicable to PACS): *each subsystem is in charge of generating its own internal HK parameters. The DPU shall transmit the request to the specific subsystems, shall read the value with the requested frequency and shall generate the corresponding packets. No check will be made that the subsystem actually sampled the parameter with the correct frequency. Only for DPU HK parameters OBS shall directly sample at the required frequency.*	AD3 Sect. 3.4.1 PERP-4 AD5 Sect. 4.5.1 AD8 IRD-TLM-R06 AD8 Sect. TBD
OBS-CUR-TM15	The OBS shall be able to 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, all sampled at a known time relative to the detector sampling time, to be included in the science data will be listed in TBD.	AD5 Sect. 4.5.2
OBS-CUR-TM16	The OBS shall be able to provide a time info in the header of all output TM packet. The TM packet time field shall report the instant in time of initiation of packet data acquisition. This time is used to determine the time at which the data in the packet was sampled	AD3 Sect. 2.1.3 TM-17 AD3 Sect. 3.1 PACK-11, PACK-12 AD5 Sect. 4.5

	and must be accurate enough (accuracy TBD) to meet the timing requirements of the instruments.	
OBS-CUR-TM17	All packets shall report information identifying to which observation/step they belong.	AD8 IRD-CMD-R11 AD8 IRD-TLM-R04
OBS-CUR-TM18	The OBS shall be able to accept the "On-target flag" transmitted by CDMS.	AD1 Sect. 5.12.6
OBS-CUR-TM19	The OBS shall be able to perform a checksum of the data included in a TM packet, and to put the result in the relevant field of the packet.	AD8 IRD-TLM-R03
OBS-CUR-TM20	The OBS shall be able to buffer telemetry packets until they are requested by the CDMS. The output TM buffer dimension (Bsize) will be: Bsize = 4 (TBC) * Tmax (TBD) * 100kbps Where Tmax (sec) is the maximum sampling period of the S/C interface (10 sec TBC, e.g AD2-S sect. 5.11.1.3).	AD8 IRD-TLM-R02
OBS-CUR-TM21	The OBS shall be able to transmit the request for a stored pointing correction to the CDMS. This request may be repeated in subsequent measurements or even in new AOTs.	AD2-H Sect. 5.12.2 AD2-P Sect. TBD AD2-S Sect. 5.12.1
	SYNCHRONISATION REQUIREMENTS	
OBS-CUR-SY01	The OBS shall be able to synchronise (with an accuracy TBD in AD1) the DPU/ICU internal clock with the CDMS master clock whenever a signal (timing synchronisation packet) is received from the CDMS.	AD3 Sect. 1.5.8 AD3 Sect. 2.1.4 TIM1 AD3 Sect. 3.8 OBTM4
OBS-CUR-SY02	The OBS shall flag, after switch on or reset, each packet (in the header time field) whenever the time has not yet been synchronised.	AD3 Sect. 2.1.4 TIM4 AD3 Sect. 3.8 OBTM5
OBS-CUR-SY03	The OBS shall send a synchronisation command to subsystems so as to synchronise the following measurement operations.	AD3 Sect. 1.5.8
OBS-CUR-SY04	The OBS shall be able to include in the TM packets all the timing info necessary to correlate their source time with TAI (with an accuracy TBD in AD1)	AD3 Sect. 2.1.4 TIM2
OBS-CUR-SY05	The OBS shall be able to hold on the command execution until a time specified by the CDMS clock or by the DPU/ICU clock (TBC) is reached.	IFSI
	OBS TESTING AND MAINTENANCE REQUIREMENTS	
OBS-CUR-SM01	Entering the instruments Test Mode shall not require disabling of fault management (autonomy) functions.	AD3 Sect.2.2.4 INFT-3
OBS-CUR-SM02	The OBS shall be able to perform regular self checks (HW and SW).	AD3 Sect. 2.2.1 AUT-10
OBS-CUR-SM03	An OBS software verification facility (for PROM, EEPROM, RAM code) shall be provided on board.	AD8 IRD-CMD-R13
OBS-CUR-SM04	The OBS shall reside in non volatile memories: PROM and EEPROM.	AD3 Sect. 3.6 OBSM-1

OBS-CUR-SM05	Functionally distinct memory areas shall be assigned on board to the following categories: - Programme code; - fixed constants; - variables and parameters.	AD3 Sect. 3.5 MM-1 AD1 Sect. 5.13.2
OBS-CUR-SM06	It shall be possible to load, dump and check the contents of either a contiguous memory area or of several non contiguous memory areas. The OBS shall be able to read from, write to and checksum areas of, the DPU/ICU EEPROM memory blocks.	AD3 Sect. 3.5 MM-2, MM-3, MM-7, MM-8, MM-10, MM-11 AD8 IRD-CMD-R13
OBS-CUR-SM07	The OBS shall be able to detect data corruptions in the loaded memory area. **Note** (from IFSI applicable to PACS): *the DPU will not be in charge of detecting data corruption in the memory area of the other subsystems.*	AD3 Sect.3.5 MM-5 AD5 Sect.4.8
OBS-CUR-SM08	The OBS shall be able to provide an answer to an "are you alive" request originating from CDMS for testing the end-to-end connection between ground and DPU/ICU.	AD3 Sect. 3.14 FTS-1, FTS-2, FTS-3
OBS-CUR-SM09	It shall be possible to stop and start tasks running in the OBS	SPIRE

3.1.2 Constraint requirements

	AUTONOMOUS FUNCTION REQUIREMENTS	
OBS-CUR-AF01	The OBS shall be able to implement pre defined procedures (health autonomy functions; TBD) on detection of DPU/ICU and other instrument subsystems anomalies.	AD2-H Sect. 5.13.3,-P,-S AD5 Sect. 4.6 AD3 Sect. 2.2.1 AUT- 9
OBS-CUR-AF02	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 (TBD) of criticality.	AD3 Sect. 2.2.1 AUT-11 AD3 Sect. 3.4.3 EVRP-1
OBS-CUR-AF03	The OBS shall be able to transmit (in event packets) reports of the adopted autonomous 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.	AD3 Sect. 2.2.1 AUT-11 AUT-12, AUT-15 AD3 Sect. 3.4.3 EVRP-3
OBS-CUR-AF04	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.	AD3 Sect. 2.1.3 TM-8 AD3 Sect. 3.4.3 EVRP-4
OBS-CUR-AF05	The OBS shall provide all the event packets with a counter which permits the unambiguous identification of missing packets.	AD3 Sect. 2.1.3 TM-18

OBS-CUR-AF06	There shall be a minimum period (TBD) before the next event packet reporting the same event (e.g. a transition to out-of-limits) can be issued.	AD3 Sect. 3.4.3 EVRP-5
OBS-CUR-AF07	Any control action requiring fast response times shall be handled on board, without any ground intervention.	AD3 Sect. 2.1.1 CTRL-1
OBS-CUR-AF08	The OBS shall be able to enable/disable on request (via a dedicated TC) each individual autonomy function.	AD3 Sect. 2.2.1 AUT-15
OBS-CUR-AF09	All parameters used for autonomous fault management shall be updateable by TC and available in TM.	AD3 Sect. 2.2.1 AUT-19
OBS-CUR-AF10	The OBS shall be able to transmit reports of normal progress of operations/activities generated by any on board function. For long execution processes, the OBS shall report in the output TM the start and the end of the process. In addition, reports of progress either periodically or at predefined steps in the execution shall be provided (TBC).	AD3 Sect. 3.4.3 EVRP-8
OBS-CUR-AF11	The initialisation of a mode shall include configuration of the necessary HW, activation of a default periodic TM configuration, and all the automatic processes required to achieve the objective of the mode.	AD3 Sect. 2.2.1 AUT-22
OBS-CUR-AF12	The OBS shall handle the warm reset of the DPU/ICU. **Note** *(from IFSI applicable to PACS: each subsystem is in charge to provide their own warm reset.*	IFSI
	TELEMETRY RATE REQUIREMENTS	
OBS-CUR-TR01	The OBS shall be able to support a total output TM rate of 100 kbps (TBC) averaged on 24 hours.	AD1 section 5.11.1 AD8 IRD-TLM-R01
OBS-CUR-TR02	The OBS shall be able to support a burst mode of 350 kbps (400 kbps for PACS) (TBC) for the output telemetry data rate.	AD1 section 5.11.6 AD8 IRD-TLM-R02

3.2 Subsystem specific requirements

3.2.1 HIFI

The HIFI instrument has been already described in many documents: for a general description refer to the block diagram reported in Figure 4.4-1 of AD2-H. The instrument consists of 5 major subsystems, which hereafter will be called units to avoid confusion with the electronics subsystems effectively interfacing with the Instrument Control Unit (ICU):

1. the ICU itself;
2. the focal plane unit, which comprises (i) the Focal Plane Unit (FPU) mounted on the 15 K vapour-cooled optical bench, containing relay optics, mixers, low-noise IF (Intermediate Frequency) HEMT pre-amplifiers, additional IF amplifiers, 4 passive power combiners and 2 3-dB couplers, providing two polarisations for the spectrometers, a focal plane chopper and a calibration source and (ii) the FPU Control Unit (FCU), operating at room temperature, which supplies the bias voltages for the mixers and IF preamplifiers in the FPU and controls the frequency diplexers, the focal plane chopper mechanism and the calibration source;

3. the local oscillator unit, which comprises (i) the Local Oscillator Unit (LOU; at about 120 K) located on the outside of the 15 K cryostat and (ii) two warm boxes: the Local oscillator Synthesiser Unit (LSU) generating the LO signal and the Local oscillator Control Unit (LCU) which controls the frequency of the local oscillator;
4. a pair of Wide-Band Spectrometers (WBS-V and WBS-H for the two polarisations), in a warm-redundancy configuration, covering a frequency range of 4 GHz with a resolution of 1 MHz;
5. a pair of High Resolution Spectrometers (HRS-V and HRS-H for the two polarisations), in a warm-redundancy configuration, covering 1 GHz. The HRSs will have two observing modes, a normal one, with 200 kHz spectral resolution, and a very high resolution mode with 100 kHz resolution.

For every integration each backend (WBS-V, WBS-H, HRS-V, HRS-H) will produce 4 (banks) times 2048 (samples) times 3 (bytes per word) = 25 kbytes.

The ICU will effectively interface with 7 subsystems: FCU, LCU, LSU, WBS-V, WBS-H, HRS-V and HRS-H. The interface between ICU and the seven subsystems will be implemented through:

1. four high speed mono-directional links (220 kHz, for WBSV-H and 2.5 MHz, for HRSV-H), for the science and HK data ICU reception;
2. one serial bi-directional low-speed bus (312.5 kHz) with seven hardware interfaces in output from ICU to the seven subsystems and three hardware interfaces in input to ICU from FCU, LCU and LSU, for the HK and command transmission/reception.

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Figure 3-1 reports the HIFI ICU OBS Context diagram: the ICU interprets the commands coming from the CDMS, sets the various subsystem parameters, controls the operation of the instrument and returns science and HK data to satellite TM system.
HIFI will have 5 operating modes, described in AD2-H Sect.4.6; the OBS shall be able to manage the instrument behaviour in all of them.

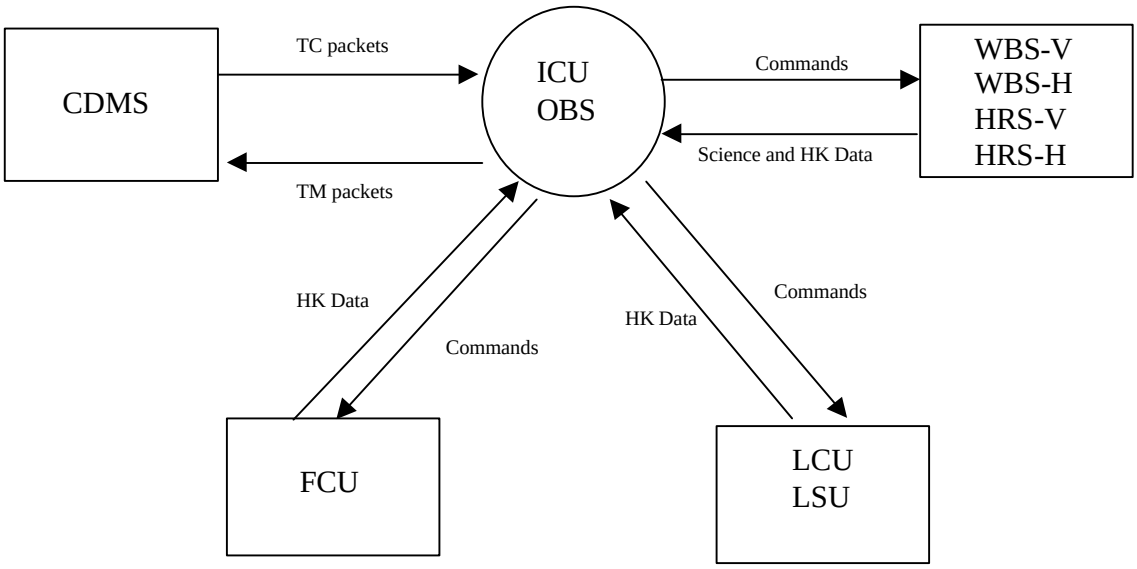

Figure 3-1 HIFI ICU On Board Software Context Diagram

3.2.1.1 HIFI Capability Requirements

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The main OBS functions lead to the definition of the following list of requirements, which will be classified as: General (GE) and Subsystems Monitoring (SM). Each requirement will be uniquely identified by the acronym OBS-HUR plus few letters indicating the previous classification and a sequential number. The communication with the subsystems shall be in accordance with the protocols specified in the HIFI Interface Control Document (AD11).

Req. ID	Description	Reference
	GENERAL REQUIREMENTS	
OBS-HUR-GE01	The OBS shall support all (5) the HIFI instrument operating modes, as described in AD2-H, Sect. 4.6: Primary, Stand-by, Test, Sleep and Off.	AD2-H Sect. 4.6
OBS-HUR-GE02	The OBS shall support all HIFI observing modes: total-power (position-switching, on-the-fly), beam-switching and frequency switching (TBC).	AD1 Annex4
OBS-HUR-GE03	The OBS shall be able to peak-up on point sources in order to correct for pointing errors. The procedure will perform a small raster scan obtaining an absolute pointing error from science data produced by one of the spectrometers.	AD2-H Sect. 5.12.2 SRON
OBS-HUR-GE04	The OBS shall be able to issue a pointing correction request to CDMS. The magnitude of the requested correction will not exceed 5 arcsec around either satellite axis.	AD2-H Sect. 5.12.2 SRON
	SUBSYSTEMS MONITORING REQUIREMENTS	
OBS-HUR-SM01	The OBS shall be able to acquire the scientific and HK data produced by the WBS-V subsystem.	AD2-H Sect. 5.13.2 AD9 Sect. 2
OBS-HUR-SM02	The OBS shall be able to acquire the scientific and HK data produced by the WBS-H subsystem.	AD2-H Sect. 5.13.2 AD9 Sect. 2
OBS-HUR-SM03	The OBS shall be able to acquire the scientific and HK data produced by the HRS-V subsystem.	AD2-H Sect. 5.13.2 AD9 Sect. 2
OBS-HUR-SM04	The OBS shall be able to acquire the scientific and HK data produced by the HRS-H subsystem.	AD2-H Sect. 5.13.2 AD9 Sect. 2
OBS-HUR-SM05	The OBS shall be able to acquire the HK data from the FCU subsystem.	AD2-H Sect. 5.13.2 AD9 Sect. 2
OBS-HUR-SM06	The OBS shall be able to acquire the HK data from the LCU subsystem.	AD2-H Sect. 5.13.2 AD9 Sect. 2
OBS-HUR-SM07	The OBS shall be able to acquire the HK data from the LSU subsystem.	AD2-H Sect. 5.13.2 AD9 Sect. 2
OBS-HUR-SM08	The OBS shall be able to monitor the status of FCU, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD9 Sect. 2
OBS-HUR-SM09	The OBS shall be able to monitor the status of LCU, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD9 Sect. 2

OBS-HUR-SM10	The OBS shall be able to monitor the status of LSU, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD9 Sect. 2
OBS-HUR-SM11	The OBS shall be able to monitor the status of WBS-V, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD9 Sect. 2
OBS-HUR-SM12	The OBS shall be able to monitor the status of WBS-H, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD9 Sect. 2
OBS-HUR-SM13	The OBS shall be able to monitor the status of HRS-V, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD9 Sect. 2
OBS-HUR-SM14	The OBS shall be able to monitor the status of HRS-H, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD9 Sect. 2
OBS-HUR-SM15	The OBS shall be able to produce event reports based on the monitor of the subsystems HK parameters.	AD3 Sect. 3.4
OBS-HUR-SM16	The OBS shall be able to select independently any combination of science data from the four 1 GHz sub-bands of each WBS-V and WBS-H.	AD2-H Sect. 4.3 SRON
OBS-HUR-SM17	The OBS shall be able to select independently any combination of science data from the four science data buffers of each HRS-V and HRS-H.	AD2-H Sect. 4.3 SRON
OBS-HUR-SM18	The OBS shall be able to co-add data from the WBSs, in both phases of the chopper or beam switching cycle.	SRON
OBS-HUR-SM19	The OBS shall be able to co-add data from the HRSs, in both phases of the chopper or beam switching cycle.	SRON
OBS-HUR-SM20	The OBS shall be able to measure IF power by retrieving the zero-lag science HRS data.	SRON
OBS-HUR-SM21	The OBS shall be able to measure IF power by averaging spectra from the WBSs.	SRON
OBS-HUR-SM22	The OBS shall be able to perform an LO power adjustment during routine operations, based on measurements of the mixer currents from the FPU.	SRON
OBS-HUR-SM23	The OBS shall be able to adjust mixer magnet currents based on measurements of the IF power level from either WBSs and HRSs.	SRON
OBS-HUR-SM24	The OBS shall be able to adjust IF power to the WBSs, based on the power measured in the WBSs.	SRON
OBS-HUR-SM25	The OBS shall be able to adjust IF power to the HRSs, based on the power measured in the HRSs.	SRON
OBS-HUR-SM26	The OBS shall be able to allow to assess, for calibration purposes, HIFI performance as a function of mixer bias voltage.	SRON
OBS-HUR-SM27	The OBS shall be able to allow to assess, for calibration purposes, the LO performance as a function of frequency.	SRON

OBS-HUR-SM28	The OBS shall be able to allow to assess, for calibration purposes, HIFI performance as a function of mixer magnetic field.	SRON

3.2.2 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 and controls the mechanical parts. The SPU can be in turn divided in two components: a low level SPU, which handles the intialisation of the unit, and a high level SPU, which processes the scientific data. The context diagram for PACS OBS is shown in Figure 3-2.

REFMERGEFORMATSTYLEREFSEQARABICThe DPU is linked to the other subsystems through IEEE-1355-1995-DS-DE serial interfaces set to a transfer rate of 10Mbps. One link is dedicated to bi-directional communications with DEC/MEC, while the SPU, which contains two DSP 21020, one for each wavelength channel, is connected to DPU with two interfaces, one for each DSP. The lines drawn in Figure 3-2 show the data flows and not the physical interfaces between subunits.

REFMERGEFORMATDepending 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 SPU through DEC/MEC.

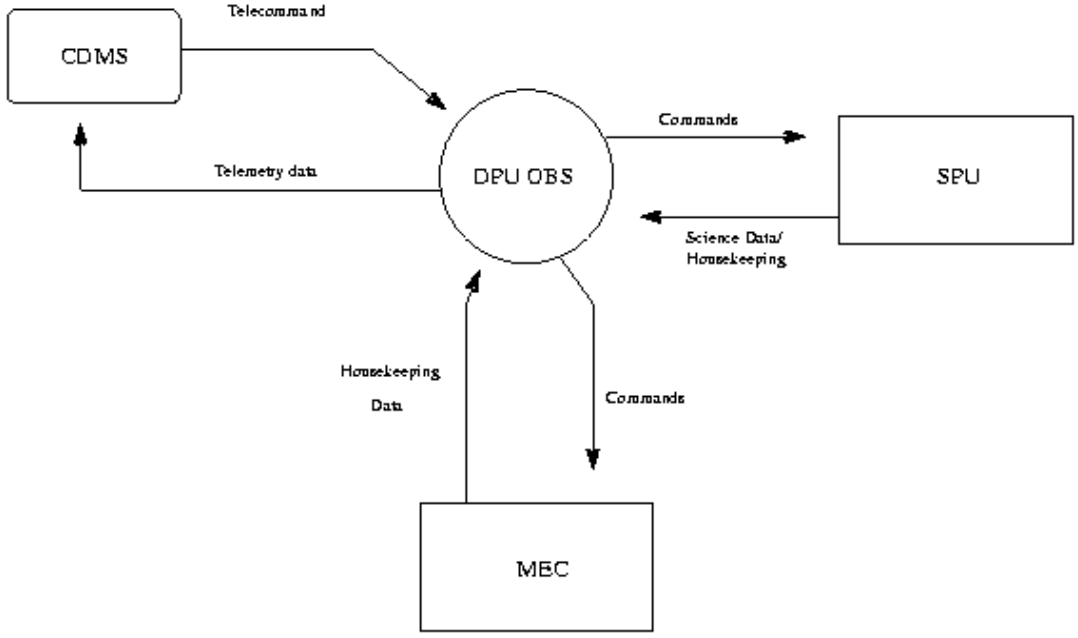

Figure 3-2 PACS DPU On Board Software Context Diagram.

3.2.2.1 PACS Capability Requirements

The OBS shall support the PACS internal commands as described in AD2-P. The bit rates for the communications with CDMS are those reported in AD2-P, at present they are (TBC):

- Housekeeping: 4kbps
- Science PACS prime mode I: 100kbps
- Science PACS prime mode II: 200kbps
- Science PACS in partner mode: 50kbps
- Science burst mode: 400kbps

The communications with the subsystems shall be in accordance with the protocol specified in the document *Communications Protocol between PACS Subsystems* (PACS-CR-TN-003). In case one of the two links with SPU breaks down, it shall be possible to use the active link to communicate with both DSP's (TBC).

Req. ID	Description	Reference
OBS-PUR-GE01	The OBS shall support all the operative modes described in AD2-P: Primary Photometer, Primary Spectrometer, Serendipity, Parallel, Standby, Recycle, Safe, Init, Off, Test	AD1
OBS-PUR-GE02	The OBS shall support all the instrument observing modes described in AD6: Dual Band Photometry, Single Band Photometry, Line Spectroscopy, Range Spectroscopy	AD2-P
OBS-PUR-GE03	The OBS shall be able to exchange memory contents with the subsystems OBS.	AD5 Sect. 4.8
OBS-PUR-GE04	The OBS shall be able to monitor the available spacecraft solid state memory, through the TM packet counters.	IFSI
	INTERFACE WITH MEC SUBSYSTEM REQUIREMENTS	
OBS-PUR-GE06	The OBS shall check that writing operations are not executed on "Read only" parameters.	IFSI (based on RD5)
OBS-PUR-GE07	The OBS shall ensure that the integration time for one detector array is equal to or an integer multiple of the other array. The action to be taken in case this condition is not fulfilled is TBD (as part of autonomous functions).	CSL
OBS-PUR-GE08	The OBS shall ensure that the detector parameters specified in a TBD list will be the same for both detector arrays. The action to be taken in case this condition is not fulfilled is TBD (as part of autonomous functions).	CSL
	INTERFACE WITH SPU SUBSYSTEM REQUIREMENTS	
OBS-PUR-GE09	The DPU shall provide to SPU, through DEC/MEC, the compression parameters specific to each observing mode. These parameters will be read in the onboard	UVIE

	tables and will be not the result of a DPU onboard computation.	
OBS-PUR-GE10	It shall always be possible to determine from which detector array scientific and HK data come, also in case the communications with SPU is done through one only link	IFSI
OBS-PUR-GE11	The OBS shall ensure that scientific data produced by the two wavelength channels are not mixed during the packetisation process	IFSI

3.2.3 **SPIRE**

The overall SPIRE warm electronics consist mainly of 2 subsystems:

- FSDPU (Digital Processing Unit): it is the warm electronics unit which provides the instrument interface to the S/C: it receives and interprets instrument commands and formats the instrument data for telemetry to the ground. In addition, the FSDPU provides the instrument control and data handling functions.
- FSDRC (Detector Read Out And Control Unit): it is a warm analogue electronics box which contains the circuitry necessary to readout the detectors and to control the various mechanisms.

FSDPU interfaces physically only with the FSDRC subsystem and with the S/C telemetry, telecommand (the S/C CDMS, Command and Data Management system) and power subsystems. The interface with the FSDRC is composed by three high speed data links (for science and housekeeping data collection) and one low speed serial bus with three output buffers (for command transmission and housekeeping data collection), of the same type as for HIFI.
The interface with the spacecraft shall be able to handle a baseline data rate of 100 kbps, with burst mode transmission up to 350 kbps (see section 3.1.2). The interface shall be compliant with the MIL-STD-1553B standard, with the FSDPU acting as a remote terminal and the CDMS as the bus controller (see section 2.2). In figure 3-3 the interface between FSDPU and FSDRC is shown schematically: a detailed description of this interface is given in RD2 and RD3.
The logical interfaces of the DPU OBS are shown in Figure 3.4.

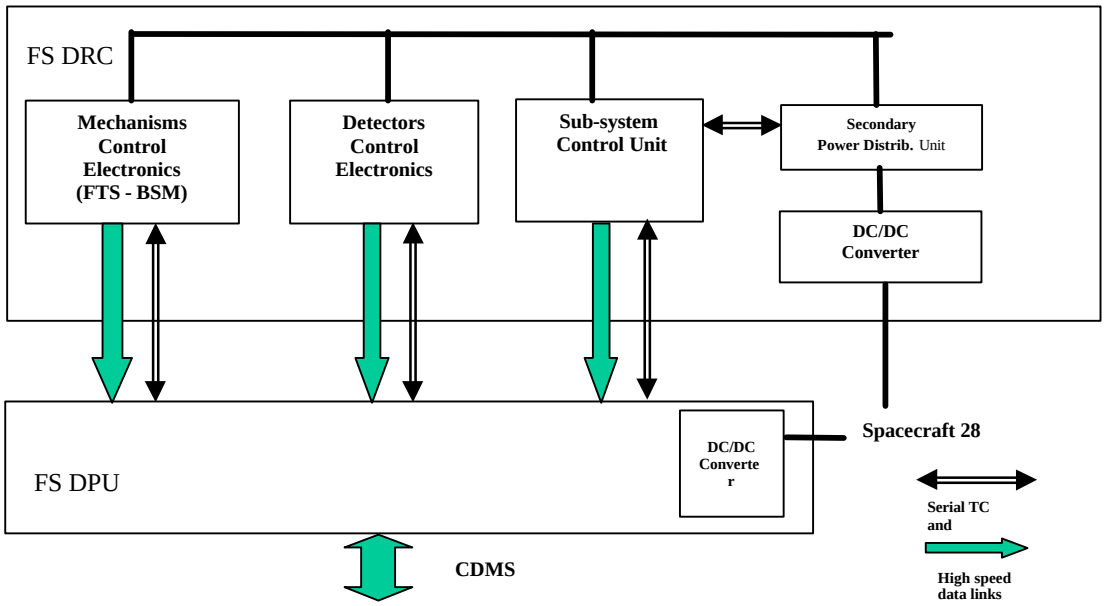

Figure 3-3 SPIRE FSDPU – FSDRC Interface block Diagram

SPIRE internal interfaces constraints:

1. Science data links: **three monodirectional fast (1 MHz clock) synchronous serial input interfaces**, each of which with 8 kw 16 Bit FIFO, are foreseen: the data can be received by the DPU at the same time.
2. Housekeeping data link: serial synchronous bus with a baseline clock speed 0.2 MHz . See RD2 and RD3 for a description of the transmission protocol.

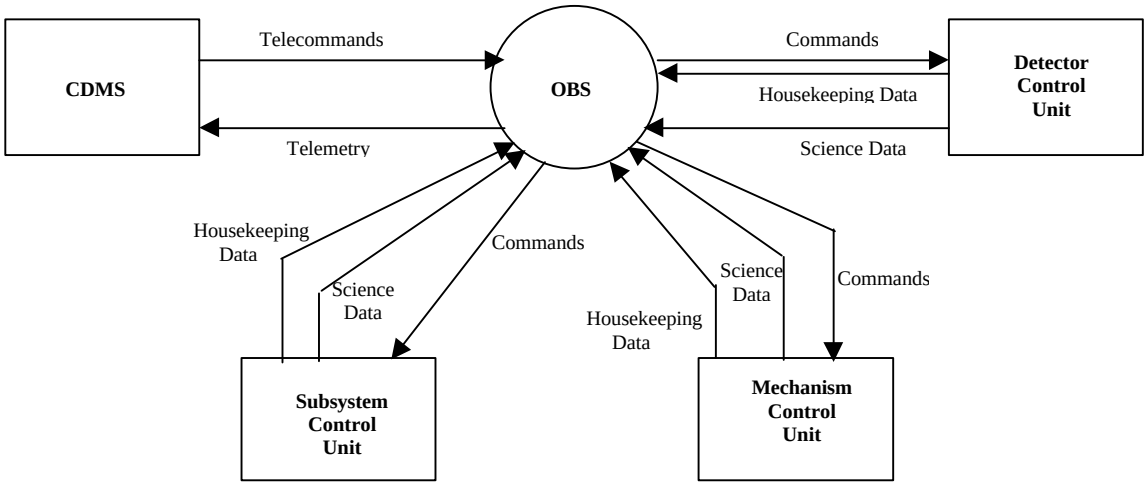

Figure 3-4 SPIRE DPU On Board Software Context Diagram

REFMERGEFORMATREFMERGEFORMATSTYLEREFSEQARABICSTYLEREFSEQARABIC**SPIRE Capability Requirements**

In addition to all the requirements listed in Section 3.1, the following requirements are applicable specifically to the SPIRE OBS:

Req. ID	Description	Reference
	Functional requirements	
OBS-SUR-FU01	The OBS shall be able to support the *Instrument commanding*, as it is defined in AD7 section 4.1 "Instrument Actions definition".	AD7 section 4.1.
OBS-SUR-FU02	The OBS shall be able to support the *Photometer Detector Control* activity, as it is defined in AD7 section 4.1 "Instrument Actions definition".	AD7 section 4.1.
OBS-SUR-FU03	The OBS shall be able to support the *Spectrometer Detector Control* Activity, as it is defined in AD7 section 4.1 "Instrument Actions definition".	AD7 section 4.1
OBS-SUR-FU04	The OBS shall be able to support the *Photometer Calibration Source Control* Activity, as it is defined in AD7 section 4.1 "Instrument Actions definition".	AD7 section 4.1
OBS-SUR-FU05	The OBS shall be able to support the *Spectrometer Calibration Source Control* Activity, as it is defined in AD7 section 4.1 "Instrument Actions definition".	AD7 section 4.1
OBS-SUR-FU06	The OBS shall be able to support the *FTS Mechanism Control* Activity, as it is defined in AD7 section 4.1 "Instrument Actions definition".	AD7 section 4.1
OBS-SUR-FU07	The OBS shall be able to support the *Beam Steering Mirror Control* Activity, as it is defined in AD7 section 4.1 "Instrument Actions definition".	AD7 section 4.1
OBS-SUR-FU08	The OBS shall be able to support the *Fridge Recycle Control* Activity, as it is defined in AD7 section 4.1 "Instrument Actions definition".	AD7 section 4.1.
OBS-SUR-FU09	The OBS shall be able to support the *Fridge Heater Control* Activity, as it is defined in AD7 section 4.1 "Instrument Actions definition".	AD7 section 4.1
OBS-SUR-FU10	The OBS shall be able to handle both the command and data interfaces between the DPU and the DRCU subsystems. The implemented communication protocols shall be compliant with the description in AD10.	AD10
OBS-SUR-FU11	The OBS shall be able to support the maximum output data rates of the following subsystems: - FTS mechanism controller; - Beam Steering Mirror; - Photometer detector array, - Spectrometer detector array, - Sorption cooler.	IFSI
	TELEMETRY REQUIREMENTS	

OBS-SUR-TM01	The OBS shall be able to provide a different nominal Science Data Packet for each observing mode.	AD8 (WE req)
OBS-SUR-TM02	The OBS shall be able to support the production of up to 8 (TBC) additional Science Data Packets.	AD8 (WE req)
OBS-SUR-TM03	The OBS shall be able to packetise the science data stream, even when the output product of a single measurement is so big that several TM packets are needed, as in the case of the raw interferograms obtained in the spectrometer high resolution observations.	AD7 Sect. 5.2.1, 5.2.2
OBS-SUR-TM04	The OBS shall be able to generate up to TBC additional types of standard HK TM packets.	AD8 (WE req)
OBS-SUR-TM05	The OBS shall be able to generate the standard HK TM packets at a different rate from the nominal (0.1 to 10 per second, TBC).	AD8 (WE req)
OBS-SUR-TM06	The OBS shall be able to generate (up to 8, TBC) Diagnostic HK data packets, at a maximum oversampling rate of 100 Hz (TBC). The transmission rate shall be selectable by command. The Diagnostic HK TM packets will contain up to 16 parameters (TBC).	AD8 (WE req)
OBS-SUR-TM07	The OBS shall be able to support the following average housekeeping and science data rates: - HK data rate (prime mode) 4.2 kbps(TBC) - Science data rate (photometer) 87 kbps(TBC) - Science data rate (spectrometer) 92 kbps(TBC) - HK data rate (non prime mode) 2.1 kbps (TBC) - Science data rate (parallel) 10 kbps (TBC) - Science data rate (serendipity) 87 kbps (TBC)	AD2-S sect. 5.11.1.1
OBS-SUR-TM08	When using the telescope scan mode, the OBS shall be able to send a TM packet to CDMS containing a "start scan" indication with a timing precision of better than 5 milliseconds.	AD2-S sect. 5.11.3
OBS-SUR-TM09	The OBS shall be able to include in the TM an OTF (on target flag) indication with a timing precision better than 0.1 sec (TBC)	AD2-S sect. 5.12.3
OBS-SUR-TM10	The OBS shall be able to support a reduction of the average data rate to CDMS to 20 kbps (e.g in case of a reduced telemetry downlink rate, by providing degraded science data packets).	AD8 IRD-DATA-R04
OBS-SUR-TM11	The OBS shall be able to support non standard data configurations: the data configurations define the environment within which the output TM data shall be provided for each instrument operating mode.	AD7 Sect.3.10
OBS-SUR-TM11.1	The OBS shall be able to handle the Commissioning Calibration (COCA) data configuration: on request, the OBS instrument monitoring functions shall be able to	AD7 Sect.3.10.1

	ignore the limits on a subset (or all) of the instrument HK parameters.	
OBS-SUR-TM11.2	The OBS shall be able to handle the Transparent (TRNS) data configuration: OBS able to collect, packetise and transmit to CDMS raw (not preprocessed or compressed) science data at the allowed rates.	AD7 Sect.3.10.2
OBS-SUR-TM11.3	The OBS shall be able to handle the TEST data configuration (a fixed configuration of the instrument is used to generate a known set of data): OBS able to receive and packetise the test data.	AD7 Sect.3.10.3
	OPERATING MODES REQUIREMENTS	
OBS-SUR-GE01	The OBS shall be able to handle all the SPIRE Instrument operating modes, described in AD7. In the following, for each one of the operating modes, an indication of the common requirements necessary to that mode is reported.	AD8 IRD-MODE-R01
OBS-SUR-GE01.1	The OBS shall be able to handle the Initialise (INIT) mode (the mode entered by the instrument after a power on or reboot). The DPU booting procedure starts with a programme resident in PROMs. The OBS in this situation will support only a limited subset of its regime functionalities, i.e. those necessary to receive TC from CDMS and to perform non volatile memory checks/updates.	AD7 Sect.3.2
OBS-SUR-GE01.2	The OBS shall be able to handle the ON mode (DPU is the only instrument subsystem switched on and initialised): • All TC reception and verification requirements applicable (DPU commanding); • Full DPU HK data to be collected and telemetered.	AD7 Sect. 3.3, 4.1
OBS-SUR-GE01.3	The OBS shall be able to handle the Ready (REDY) mode (DPU and DRCU powered on and OBS ready to receive commands): • All common requirements applicable (with the HK collection limited to the DRCU data).	AD7 Sect.3.4, 4.1
OBS-SUR-GE01.4	The OBS shall be able to handle the Standby (STBY) mode: • All common requirements applicable; • OBS able to handle the I/Fs with the other instrument subsystems; • OBS able to collect and transmit some limited science data (photometer detectors on at 300mk, all other subsystems switched off, TBC); • OBS shall support a transmission rate very much lower than the full TM bandwidth.	AD7 Sect.3.5, 4.1

OBS-SUR-GE01.5	The OBS shall be able to handle the Cooler Recycle (CREC) mode: • OBS able to support other subsystems switch off; • OBS shall be able to collect and monitor vital HK information (e.g. on cooler parameters); • OBS to support the *Fridge Recycle Control* Activity	AD7 Sect.3.7, 4.1
OBS-SUR-GE01.6	The OBS shall be able to handle the SAFE mode: • OBS able to manage unrecoverable anomalies. • OBS able to handle HK data • OBS able to run under a restricted environment (a restricted set of software stored in ROM, see RD2 for a description of the ROM software functions).	AD7 Sect.3.8, 4.1 AD3 Sect. 2.1.1 CTRL-4
OBS-SUR-GE01.7	The OBS shall be able to support the two basic sub-modes for the Observe (OBSV) mode and shall implement the on-board data processing as descripted in AD7. • Photometer mode: in this mode 9 different observatory functions are foreseen; • Spectrometer mode: in this mode 2 different observatory functions are foreseen.	AD7 Sect.3.6 AD7 Sect. 5 (TBC)
OBS-SUR-GE01.8	The OBS shall be able to acquire all Photometer detector pixels corresponding to a 4'x8' FOV (288 detectors) at a maximum readout frequency of 16 Hz per frame and 16 bits per sample.	AD7 Sect. 5 (TBC)
OBS-SUR-GE01.9	The OBS shall be able to acquire all Spectrometer detector pixels corresponding to a 2.6'x2.6' FOV (56 detectors) at a maximum readout frequency of 80 Hz per frame and 16 bits per sample.	AD7 Sect. 5 (TBC)
OBS-SUR-GE01.10	When the instrument operates in chopped modes, the OBS shall be able to implement a correct synchronisation between BSM movements and detectors sampling. The timing scheme and the subsystems commanding sequence is TBD in AD7.	AD7 Sect. 5 (TBC)