FIRST

DPU/ICU On Board Software

User Requirements Document

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Issue	**Revision**	**Date**	**Reason for Change**
Draft 0		05/11/1999	First draft for each instrument
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
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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

The astronomical satellite FIRST will host on-board 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

[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.

CDMS	Command and Data Management Subsystem
CNR	Consiglio Nazionale delle Ricerche
CPU	Control Processing Unit
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
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
IFSI	Istituto di Fisica dello Spazio Interplanetario
LCU	LO Control Unit
LO	Local Oscillator
LSB	Least Significant Bit
LSU	LO Source Unit
MEC	Mechanical Control unit
MOC	Mission Operations Centre
MSB	Most Significant Bit
OBCP	On-Board Control Procedure
OBS	On-Board Software
OIRD	Operations Interface Requirements Document
PACS	Photoconductor Array Camera and Spectrometer
PCS	Permanent Command Sequence
PLM	PayLoad Module
PROM	Programmable Read Only Memory
RAM	Random Access Memory
ROM	Read Only Memory
SID	Structure ID
SPIRE	Spectral and Photometric Imaging Receiver
SPU	Signal Processing Unit
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, Draft 0-3, 15 May 2000
AD2-P	FIRST/Planck Instrument Interface Document Part B Instrument "PACS"	PT-PACS-02126, Draft 0-3 10 May 2000
AD2-S	FIRST/Planck Instrument Interface Document Part B Instrument "SPIRE"	PT-SPIRE-02124 Draft 0-4 15 May 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 Oct. 1999
AD6	Minutes of OBS-URD meeting n.1	Rome 10 Nov. 1999
AD7	HIFI proposal, Part I, Scientific and Technical Plan.	February 1998
AD8	PACS Consortium Meeting N. 8 . Appendix 25	
AD9	MFCU-DPU interface description and list of commands	PACS-CL-TN-003. 15 June 1999
AD10	SPU requirements specification.	PACS-IAC-SP-001. 24 September1999
AD11	SPIRE Warm Electronics Requirements document	Draft 0.2, 10 Aug.99
AD12	Operating Modes for the SPIRE Instruments	SPIRE-RAL-DOC-000320 Draft 0.22, 25 May 2000
AD13	SPIRE Instrument Requirements document	SPIRE/RAL/N/0034 Draft 0.3 May 2000
AD14	FIRST Operations Scenario Document	Draft 0.95, 22 February 2000
AD15	S/C to instruments interface Transfer Layer protocol for FIRST/Planck Mission	TBW

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
RD2	FIRST SPIRE DPU subsystem specification document	Draft 1 – 23/05/2000
RD3	FIRST SPIRE DPU-DRCU Interfaces	Draft 1 – 18/05/2000
RD2	FIRST HIFI ICU subsystem specification document	Draft 1 – 29/05/2000

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, and provides the reader with 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

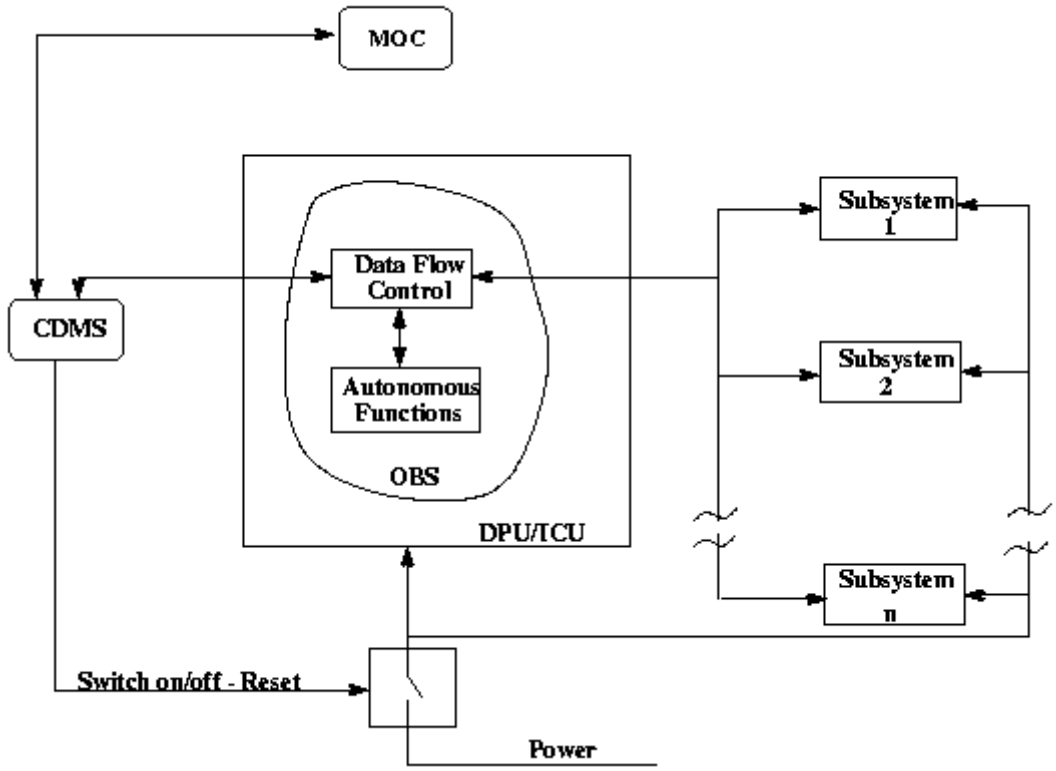

Figure 2-1 *High level functionality of DPU/ICU OBS: dialogue with subsystems and check of health status of the instrument (autonomous functions). On the basis of the HK parameters values DPU/ICU can ask CDMS to switch off part or the whole instrument. To simplify the figure only one power line has been 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.
TM will be structured in three types of packets: science, HK and event. 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 AD12, for PACS in ……., for HIFI in …….

2.2 General constraints

- Ground contact during the routine science mission phase:
  ground station contact and real time control will take place during a few hours per day (2 TBC). 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, including HK and events (TBC);
    6. Burst mode bit rate is 300Kbps;
    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 (baseline):
    - PROM = 32 KB
    - EEPROM = 512KB
    - Program RAM = 760KB
    - Data RAM = 1MB
  - 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 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 the serial interface 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;
- Science data acquisition and packetisation;
- HK data packetisation (and acquisition, in the case of HIFI);
- Transmission of data (science and HK) from the instrument to the CDMS;
- 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.

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;
- Memory load and dump, EEPROM write and check.

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

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

[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

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
FUN 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 simple writing/reading operations.	IFSI
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. In case of any failure this report shall clearly state which test failed and why.	IFSI

OBS-CUR-ON04	This event report 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) direct command to a subsystem; b) execute a function in the DPU; c) interpret a procedure in the DPU.	AD5 AD13 IRD-CMD-R09
OBS-CUR-TC02	The OBS shall be able to: a) update/add a SW function; b) update/add a procedure.	AD5 AD13 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 (AD15).	AD3 Sect. 1.5.1 AD15 AD13 IRD-DATA-R01
OBS-CUR-TC04	The OBS shall receive, unpack and process all the uplinked command packets at the maximum command data rate (2 TC per second, AD1 section 5.11.4), regardless of packet sizes. **Note**: *it should be noted that processing the command packets does not imply executing the command.*	AD3 Sect. 2.1.1 CTRL5, CTRL-6 AD13 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	AD3 Sect. 3.2 TCV-0 AD4 Sect. 3.1.2.1

	TC. The acknowledge acceptance is mandatory.	
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 AD13 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 AD13 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 AD13 IRD-CMD-R02
OBS-CUR-TC11	The OBS shall generate an event 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 AD13 IRD-CMD-R04
OBS-CUR-TC11.1	The OBS shall generate the telecommand verification report within TBD sec from the reception of the TC.	AD3 Sect. 3.2 TCV-7 AD13 IRD-CMD-R04
OBS-CUR-TC12	The OBS shall generate an event 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 AD13 IRD-CMD-R04
OBS-CUR-TC13	The OBS shall transmit the commands to the relevant subsystems of the instruments.	AD7 Sect. 3.6.1 AD2-S, AD8
OBS-CUR-TC14	The OBS shall be able to generate event reports containing a progress report (on request) or anomaly report reflecting the completion status (success or failure) of the stages of the TC execution process.	AD3 Sect. 3.2 TCV-3 AD13 IRD-CMD-R03 IRD-CMD-R04
OBS-CUR-TC15	The OBS shall generate a TM event packet for unsuccessful command execution.	AD3 Sect. 3.2 TCV-4 AD13 IRD-CMD-R04
OBS-CUR-TC16	The OBS shall pack the event reports according to AD4: ESA packet telemetry standards (via a TBW protocol to adapt AD4 to MIL-STD-1553B, AD15).	AD5 Sect. 4.3
OBS-CUR-TC17	The OBS shall be able to abort the current command execution whenever a special control TC is received.	AD5 Sect. 4.1 AD13 IRD-CMD-R10
OBS-CUR-TC18	The OBS shall support the possibility of updating, via dedicated TCs, all the parameters tables stored on-board.	AD3 Sect. 3.2 TC-9 AD13 IRD-CMD-R12
OBS-CUR-TC19	The OBS shall interrupt, if requested by CDMS, the transmission to CDMS of TC verification packets.	AD3 sect 3.2 TCV-5
OBS-CUR-TC20	The OBS shall identify lost commands (by a jump in	SPIRE

	the TC packet counter) and report this in an event packet.	
OBS-CUR-TC21	The OBS shall be able to execute a peak-up procedure to evaluate an attitude offset for a pointing correction. The pointing as a function of time is determined by the AOT logic and will be available in form of macro parameters. **Note:** *This requirement is applicable to HIFI and may be applicable to SPIRE also. The details of the peak-up procedure are 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 AD15.	IFSI AD11 FUN 3.1
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 AD13 IRD-TLM-R05 AD11 FUN 3.3
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 AD11 FUN 3.3
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 (AD15).	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. **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*".	AD3 Sect. 3.4.1 PERP-6 (AD3 Sect. 3.1 PACK-9 see note) 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	AD3 Sect. 3.4.1 PERP-5

	to be included into the HK/diagnostic TM.	
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.	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-TM12.1	The OBS shall be able to generate up to TBC additional types of standard HK TM packets.	AD11 FUN-3.3.1.2 AD13 IRD-TLM-R06
OBS-CUR-TM13	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 AD13 IRD-TLM-R06 AD11 FUN-3.3.2
OBS-CUR-TM14	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-TM15	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 and must be accurate enough (accuracy TBD) to meet the timing requirements of the instruments.	AD3 Sect. 2.1.3 TM-17 AD3 Sect. 3.1 PACK-11, PACK-12 AD5 Sect. 4.5
OBS-CUR-TM16	All packets shall report information identifying to which observation/step they belong.	AD13 IRD-CMD-R11 AD13 IRD-TLM-R04
OBS-CUR-TM17	The OBS shall be able to accept the "On-target flag" transmitted by CDMS.	AD1 Sect. 5.12.6
OBS-CUR-TM18	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.	AD13 IRD-TLM-R03
OBS-CUR-TM19	The OBS shall be able to buffer telemetry packets until	AD13 IRD-TLM-R02

	thay are requested by the CDMS. The output TM buffer dimension 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).	
OBS-CUR-TM20	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).	AD13 IRD-DATA-R04
OBS-CUR-TM21	The OBS shall be able to send attitude update request data packet to CDMS. **Note:** *This requirement is applicable to HIFI and SPIRE(TBC).*	AD2-S Sect. 5.12.1
	SYNCHRONISATION REQUIREMENTS	
OBS-CUR-SY01	The OBS shall be able to synchronise (with a 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 a 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.	
	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.	AD13 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	AD3 Sect. 3.5 MM-2, MM-3, MM-7, MM-11, MM8, MM10

	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. **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.*	AD13 IRD-CMD-R13
OBS-CUR-SM07	The OBS shall be able to detect data corruptions in the loaded memory area.	AD3 Sect.3.5 MM-5 AD5 Sect.4.8
OBS-CUR-SM08	The OBS shall be able to exchange memory contents with the subsystems OBS. **Note:** *this requirement is valid only for PACS* .	AD5 Sect. 4.8
OBS-CUR-SM09	It shall be possible to load, via a dedicated TC, replacement and/or additional On board software procedures.	AD5 Sect. 3.2.2 AD13 IRD-CMD-R13
OBS-CUR-SM10	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-SM11	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,-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	AD3 Sect. 3.4.3 EVRP-5

	next event packet reporting the same event (e.g. a transition to out-of-limits) can be issued.	
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
	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 AD13 IRD-TLM-R01
OBS-CUR-TR02	The OBS shall be able to support a burst mode of 300 Kbps (TBC) for the output telemetry data rate.	AD1 section 5.11.6 AD13 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 22 of the Part I of the proposal (Scientific and Technical Plan; AD7). The instrument consists of 5 major subsystems, which hereinafter 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) inside the cryostat, containing relay optics, mixers, low-noise IF (Intermediate Frequency) HEMT pre-amplifiers, a focal plane chopper and a calibration source and (ii) the FPU Control Unit (FCU) 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 inside the cryostat and (ii) two warm boxes: the Local-Oscillator Source Unit (LSU) generating the LO signal and the LSU Control Unit (LCU) which controls the frequency of the local oscillator;
4. a pair of wide-band spectrometers (WBSV and WBSH for the two polarisations), in a warm-redundancy configuration;

5. a pair of high resolution spectrometers (HRSV and HRSH for the two polarisations), in a warm-redundancy configuration.

The ICU will effectively interface with 7 subsystems: FCU, LCU, LSU, WBSV, WBSH, HRSV and HRSH. The interface between ICU and the seven subsystems will be implemented through:

1. four high speed mono-directional links (212 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 (200 KHz) with seven hardware interfaces in output from ICU and three hardware interfaces in input to ICU with the seven subsystems, for the HK and command transmission/reception.

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 4 (TBC) operating modes, described in AD2-H Sect.4.6; the OBS shall be able to manage the instrument behaviour in all of them.

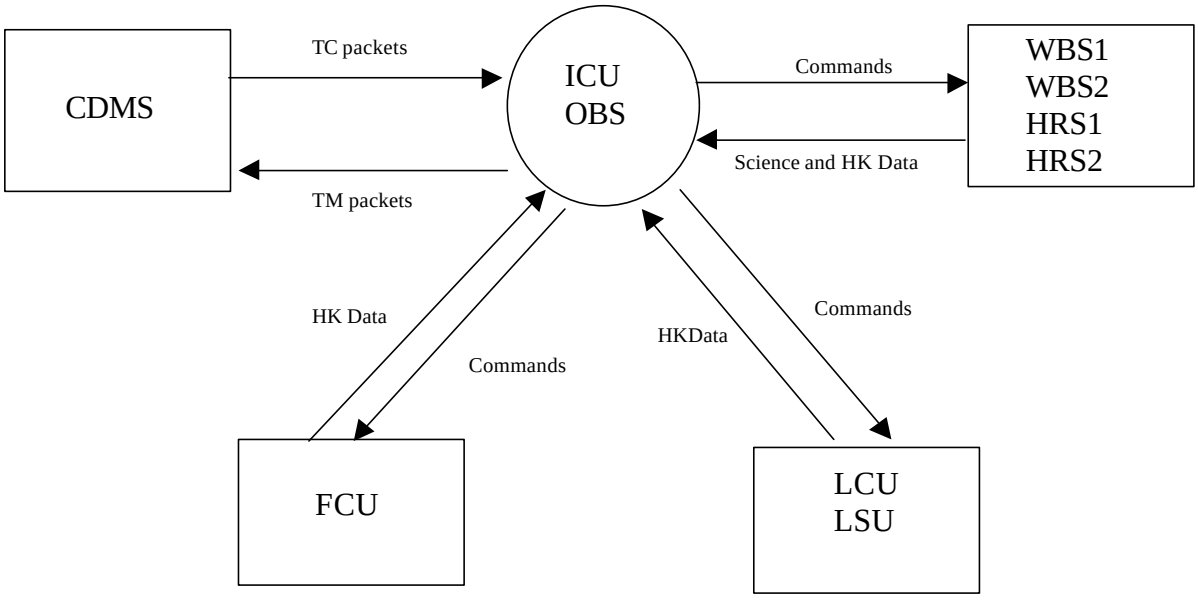

Figure 3-1 HIFI ICU On Board Software Context Diagram

3.2.1.1 HIFI Capability Requirements

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.

Req. ID	Description	Reference
	GENERAL REQUIREMENTS	
OBS-HUR-GE01	The OBS shall support all the HIFI instrument operating modes, as described in AD2-H, Sect. 4.6: primary operating, stand-by, test, off. **Note:** *the other two modes listed in AD2-H (FPU and/or LSU operations at ambient temperature) should be regarded as extra variations in test mode.*	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.	AD7 Sect. 3.7.1
OBS-HUR-GE03	The OBS shall be able to perform optimisation procedures, based on subsystem outputs according to specified algorithms provided by subsystems developers.	AD2-H
	SUBSYSTEMS MONITORING REQUIREMENTS	
OBS-HUR-SM01	To acquire the scientific and HK data produced by the WBSV subsystem.	AD2-H Sect. 5.13.2 AD7 Sect. 3.6.1
OBS-HUR-SM02	To acquire the scientific and HK data produced by the WBSH subsystem.	AD2-H Sect. 5.13.2 AD7 Sect. 3.6.1
OBS-HUR-SM03	To acquire the scientific and HK data produced by the HRSV subsystem.	AD2-H Sect. 5.13.2 AD7 Sect. 3.6.1
OBS-HUR-SM04	To acquire the scientific and HK data produced by the HRSH subsystem.	AD2-H Sect. 5.13.2 AD7 Sect. 3.6.1
OBS-HUR-SM05	To acquire the HK data from the FCU subsystem.	AD2-H Sect. 5.13.2 AD7 Sect. 3.6.1
OBS-HUR-SM06	To acquire the HK data from the LCU subsystem.	AD2-H Sect. 5.13.2 AD7 Sect. 3.6.1
OBS-HUR-SM07	To acquire the HK data from the LSU subsystem.	AD2-H Sect. 5.13.2 AD7 Sect. 3.6.1
OBS-HUR-SM08	To monitor the status of FCU, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD7 Sect. 3.6.1
OBS-HUR-SM09	To monitor the status of LCU, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD7 Sect. 3.6.1
OBS-HUR-SM10	To monitor the status of LSU, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD7 Sect. 3.6.1
OBS-HUR-SM11	To monitor the status of WBSV, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD7 Sect. 3.6.1

OBS-HUR-SM12	To monitor the status of WBSH, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD7 Sect. 3.6.1
OBS-HUR-SM13	To monitor the status of HRSV, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD7 Sect. 3.6.1
OBS-HUR-SM14	To monitor the status of HRSH, based on parameters of the subsystem monitored by ICU itself.	AD3 Sect. 3.4 AD5 Sect. 4.6 AD7 Sect. 3.6.1
OBS-HUR-SM15	To produce event reports based on the monitor of the subsystems HK parameters.	AD3 Sect. 3.4

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 reads the detectors and controls the mechanical parts and drives the detectors. The context diagram for PACS OBS is shown in Figure 3-2.

The DPU is linked to the other subsystems through three high speed serial interfaces: one toward DEC/MEC and two with SPU, one for each detector array. A copy of DEC/MEC commands will be sent to SPU in order to prewarn the subunit about the setting of the mechanisms in the FPU and the timing of the incoming detector data. This data flow is shown with the dotted line in to remind that the copy will be routed through the interfaces with SPU.

The serial interfaces are IEEE-1355-1995-DS-DE which will be set to a 10Mbps bi-directional.

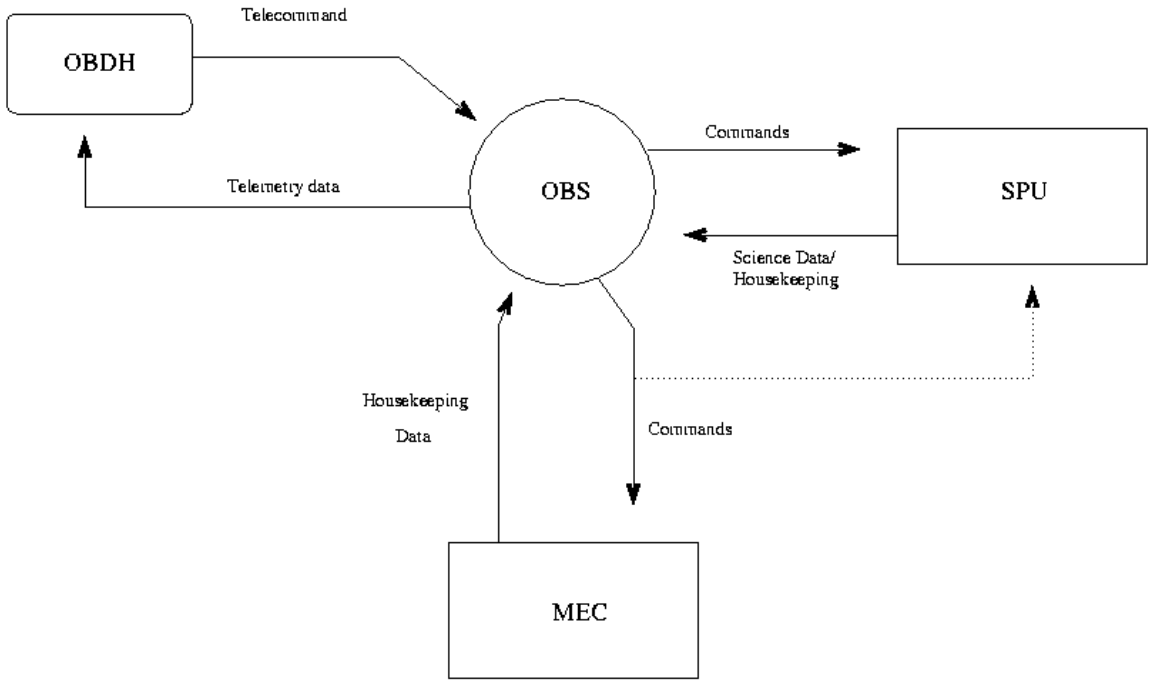

Figure 3-4 PACS On-board DPU Software Context Diagram.

3.2.2.1 PACS Capability Requirements

The OBDS shall support the following PACS internal commands (AD8):

- Single commands: mnemonic + parameter
- Dummy commands: text information to structure the command queue
- ICS: sequence of commands with partly undefined parameters
- PCS: sequence of commands completely defined

The following bit-rates are currently foreseen (from AD2-P, TBC): 400 Kbs (burst mode 1); 200 Kbs (prime mode II); 100 Kbs (prime mode I); 50 Kbs (partner mode).

Req. ID	Description	Reference
OBS-PUR-GE01	The OBS shall support all the operative modes described in AD2-P.	AD1
	INTERFACE WITH MEC SUBSYSTEM REQUIREMENTS	
OBS-PUR-GE02	Data sent to DEC/MEC shall be delimited by “end of message” control characters.	AD9
OBS-PUR-GE03	Any command sent to the DEC/MEC shall be identifiable as “Read/Write'” or “Trigger” type.	AD9
OBS-PUR-GE04	A “Read/Write” command shall correspond to a reading or writing operation performed by the OBS in the DEC/MEC memory space visible from DPU.	AD9
OBS-PUR-GE05	Any command of type “Read/Write” shall uniquely identify the target memory area by specifying the starting address and range.	AD9 (substitutes AD3 Sect. 3.5 MM-3, MM-8)
OBS-PUR-GE06	The OBS shall check that writing operations are not executed on “Read only” parameters.	IFSI (based on AD9)
	INTERFACE WITH SPU SUBSYSTEM REQUIREMENTS	
OBS-PUR-GE07	OBS shall always provide SPU with a copy of any TC sent to DEC/MEC.	AD8
OBS-PUR-GE08	The DPU shall provide to SPU the compression parameters specific to each operative mode. These parameters will be read in the onboard tables and will be not the result of a DPU onboard computation.	UVIE
OBS-PUR-GE09	It shall always be possible to determine from which detector array scientific and HK data come.	IFSI
OBS-PUR-GE10	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 fullfilled is to be defined (autonomous functions).	

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 Data readout and Control Unit subsystem and with the S/C telemetry, telecommand (the S/C CDMS, Command and Data Management system) and power systems.
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 kbit/s, with burst mode transmission up to 300 kbit/s (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 DPU and DRCU is shown schematically: a detailed description of this interface is given in RD2 and RD3.
The logical interfaces of the OBS are shown in figure 3.4.

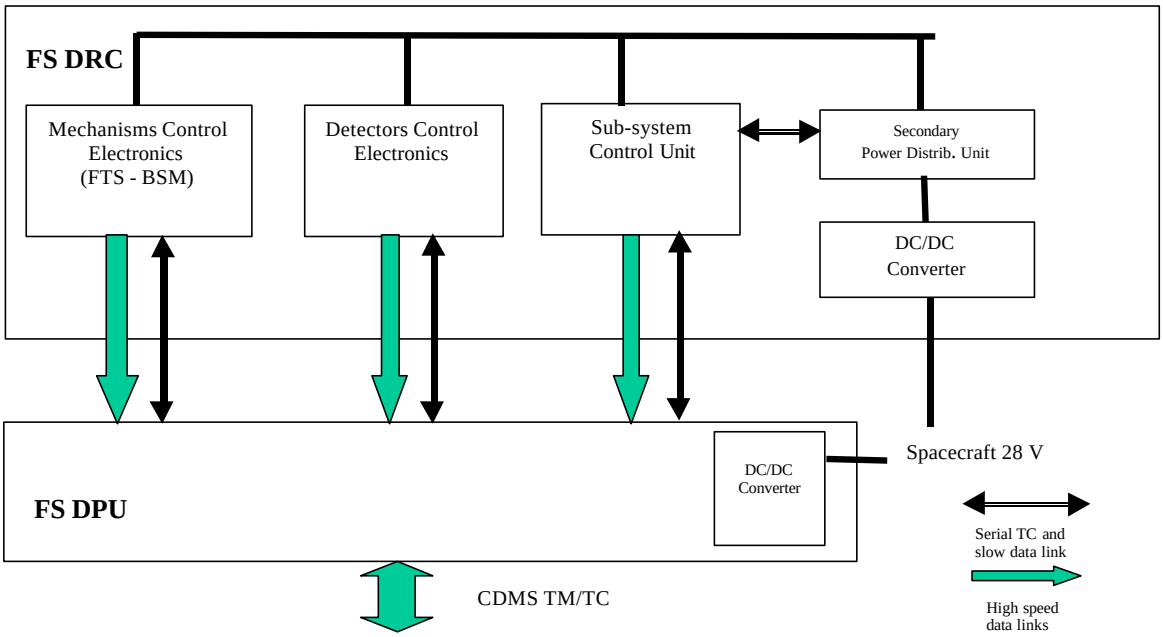

Figure 3-3 SPIRE FSDPU – FSDRC Interface block Diagram

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.

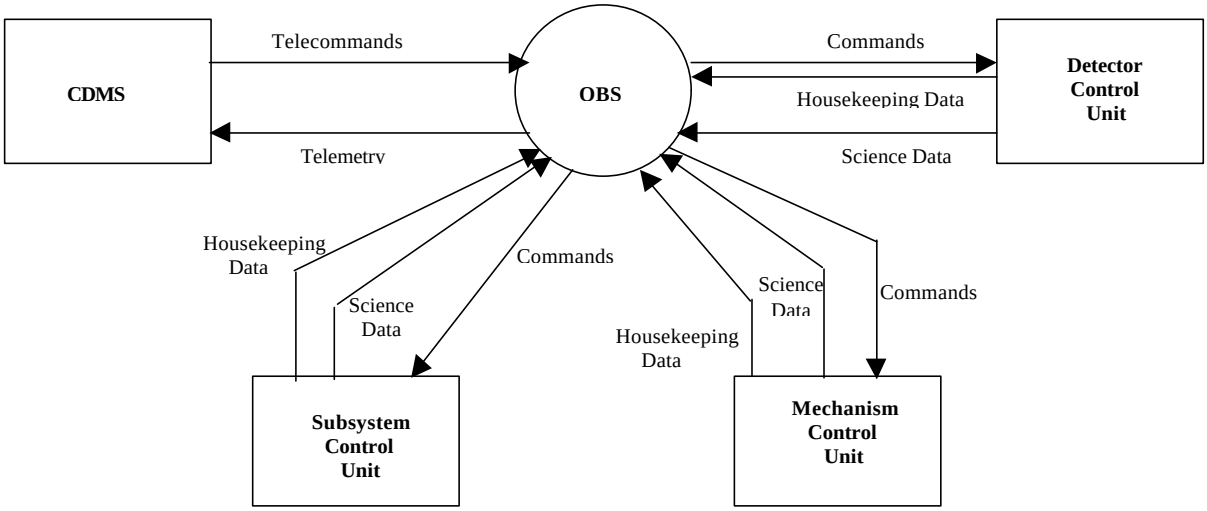

Figure 3-4 SPIRE DPU On Board Software Context Diagram

3.2.3.1 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 AD12 section 4.1 "Instrument Actions definition".	AD12 section 4.1.
OBS-SUR-FU02	The OBS shall be able to support the *Photometer Detector Control* activity, as it is defined in AD12 section 4.1 "Instrument Actions definition".	AD12 section 4.1.
OBS-SUR-FU03	The OBS shall be able to support the *Spectrometer Detector Control* Activity, as it is defined in AD12 section 4.1 "Instrument Actions definition".	AD12 section 4.1
OBS-SUR-FU04	The OBS shall be able to support the *Photometer Calibration Source Control* Activity, as it is defined in AD12 section 4.1 "Instrument Actions definition".	AD12 section 4.1
OBS-SUR-FU05	The OBS shall be able to support the *Spectrometer Calibration Source Control* Activity, as it is defined in AD12 section 4.1 "Instrument Actions definition".	AD12 section 4.1
OBS-SUR-FU06	The OBS shall be able to support the *FTS Mechanism Control* Activity, as it is defined in AD12 section 4.1 "Instrument Actions definition".	AD12 section 4.1
OBS-SUR-FU07	The OBS shall be able to support the *Beam Steering Mirror Control* Activity, as it is defined in AD12 section 4.1 "Instrument Actions definition".	AD12 section 4.1
OBS-SUR-FU08	The OBS shall be able to support the *Fridge Recycle Control* Activity, as it is defined in AD12 section 4.1 "Instrument Actions definition".	AD12 section 4.1.
OBS-SUR-FU09	The OBS shall be able to support the *Fridge Heater Control* Activity, as it is defined in AD12 section 4.1 "Instrument Actions definition".	AD12 section 4.1
OBS-SUR-FU10	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.	
OBS-SUR-FU11	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.	
OBS-SUR-FU12	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.	
OBS-SUR-FU13	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 AD12.	
	TELEMETRY REQUIREMENTS	
OBS-SUR-TM01	The OBS shall be able to provide a different nominal Science Data Packet for each observing mode.	AD11 FUN-3.1
OBS-SUR-TM02	The OBS shall be able to support the production of up to 8 (TBC) additional Science Data Packets.	AD11 FUN-3.2
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.	AD12 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.	AD11 FUN-3.3.1.2
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).	AD11 FUN-3.3.1.1
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).	AD11 FUN-3.3.2 FUN-3.3.2.1
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
	OPERATING MODES REQUIREMENTS	
OBS-SUR-GE01	The OBS shall be able to handle all the SPIRE Instrument operating modes, described in AD12. In the following, for each one of the operating modes, an indication of the common requirements necessary to that mode is reported.	AD13 IRD-MODE-R01 AD11 FUN-1

OBS-SUR-GE01.1	The OBS shall be able to handle the ON mode: • All TC reception and verification requirements applicable (DPU and DRCU commanding); • Full DPU HK data to be telemetered.	AD11 FUN-1.1 AD12 Sect.4.1
OBS-SUR-GE01.2	The OBS shall be able to handle the OFF mode: • OBS able to support other subsystems switch off (before the switch off of the DPU itself).	AD12 Sect.4.1
OBS-SUR-GE01.3	The OBS shall be able to handle the Initialise (INIT) mode (the mode entered by the instrument after a power on or reboot): • All Switch On requirements applicable • OBS able to support S/W updates. • OBS able to support memory load • All TC reception and verification requirements applicable (DPU commanding) • All DPU HK handling requirements applicable.	AD12 Sect.4.1
OBS-SUR-GE01.4	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 (i.e. TCs generation , HK TM, autonomous operation and event generation, synchronisation)	AD12 Sect.4.1
OBS-SUR-GE01.5	The OBS shall be able to handle the Standby (STBY) mode: • OBS able to collect and transmit HK info; • 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.	AD12 Sect.4.1
OBS-SUR-GE01.6	The OBS shall be able to handle the Commissioning Calibration (COCA) mode: • All common requirements applicable (i.e. TCs generation, HK TM, autonomous operation and event generation, synchronisation) • OBS shall be able to ignore the limits on selected health check parameters.	AD12 Sect.3.10
OBS-SUR-GE01.7	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 *Fridge Recycle Control* Activity	AD12 Sect.4.1
OBS-SUR-GE01.8	The OBS shall be able to handle the SAFE mode: • OBS able to manage unrecoverable anomalies. • OBS able to handle HK data	AD12 Sect.4.1 AD3 Sect. 2.1.1 CTRL-4

	• 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).	
OBS-SUR-GE01.9	The OBS shall be able to handle the Transparent (TRNS) mode: • OBS able to collect, packetise and transmit to CDMS raw (not compressed) science data at the allowed rates.	AD12 Sect.3.10
OBS-SUR-GE01.10	The OBS shall be able to handle the TEST mode: • All TC reception and verification requirements applicable; • OBS able to receive and packetise the test scientific data.	AD12 Sect.3.10
OBS-SUR-GE01.11	The OBS shall be able to support the two basic sub-modes for the Observe (OBSV) mode: • Photometer mode • Spectrometer mode In both cases the data collected and processed by the DRCU from the Instrument detectors (3 Photom. Detectors at a 40 Hz sampling rate, chopping mode, or 28 Hz, scanning mode, and 2 spectrometer detectors at a 200 Hz sampling rate), will be passed to DPU for packetisation and transmission to the CDMS.	AD12 Sect.4.1
OBS-SUR-GE01.13	Shall be able to packetise photometer data at a rate of TBD image per second.	AD11 PER-4
OBS-SUR-GE01.14	Shall be able to packetise spectrometer data at a rate of TBD image per second.	AD11 PER-5
OBS-SUR-GE01.15	The OBS shall be able to cope with degraded modes.	AD11 REL-3