

 <p>IFSI CNR</p>	<p>FIRST DPU/ICU Subsystem Development Plan</p>	<p>Ref.: F-13.06.00 Issue: 1 Date: 13/06/00</p>
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FIRST- DPU/ICU

Subsystem Development Plan

Document Ref.: F-13.06.00

Issue: 1

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1 Scope of the document

This document describes the development plan of the FIRST Data Processing Unit:

PACS DPU

HIFI ICU.

SPIRE DPU

The development plan is based on the applicable documents cited in paragraph #2.

2 Documents

2.1 Applicable documents

Document Reference	Name	Number/version/date
AD1	FIRST/Planck Instrument Interface Document Part A	PT-IID-A-04624 Draft 0 30 Sept 1997
AD2	FIRST/Planck Instrument Interface Document Part B Instrument "PACS"	
AD3	FIRST/Planck Instrument Interface Document Part B Instrument "HIFI"	
AD4	FIRST/Planck Instrument Interface Document Part B Instrument "SPIRE"	PT-SPIRE-02124 Issue 0.2 01 Aug. 1999
AD5	PACS Development plan	
AD6	HIFI Development plan	To be written
AD7	SPIRE Development plan	To be written

2.2 Reference documents

	Title	Author	Reference	Date
RD1	SPIRE Instrument Requirements Document	B.M.Swinyard	SPIRE-RAL-PRJ-000034 Iss .30	May 2000
RD2	SPIRE Instrument Development Plan	K.King	SPIRE WE Review viewgraphs	6 Dec 1999

2.3 Glossary

AD	Architectural Design
ADx	Applicable Document N. x
ASCII	American Standard Code for Information Interchange
ATP	Acceptance Test Plan
AVM	Avionic Model
CASE	Computer Aided Software Engineering
CNR	Consiglio Nazionale delle Ricerche
CPU	Control Processing Unit
DDD	Detailed Design Document
DPU	Digital Processing Unit

DRCU	Detector Readout Control Unit
EEPROM	Electrically Erasable Programmable Read Only Memory
EGSE	Electronic Ground Support Equipment
ESA	European Space Agency
FIRST	Far InfraRed and Submillimeter Telescope
HIFI	Heterodyne Instrument for FIRST
HK	HouseKeeping
HW	HardWare
IBDR	Instrument Baseline Design Review
ICD	Interface Control Document
ICDR	Instrument Critical Design Review
ICU	Instrument Control Unit
IHDR	Instrument Hardware Design Review
I/F	Interface
IFSI	Istituto di Fisica dello Spazio Interplanetario
ISVR	Instrument Science Verification Review
NCR	Non Conformance report
OBS	On-Board Software
PACS	Photoconductor Array Camera and Spectrometer
PA	Product Assurance
QA	Quality Assurance
RID	Review Item Discrepancy
S/C	Spacecraft
S/S	Subsystem
SCCS	Source Code Control System
SCR	Software Change Request
SPIRE	Spectral and Photometric Imaging REceiver
SPR	Software Problem Report
SPU	Signal Processing Unit
SR	Software Requirement
SSD	Software Specification Document
SVVP	Software Verification and Validation Plan
SW	SoftWare
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
UR	User Requirement
URD	UR Document
WP	Work Package

3 Description of the DPU subsystem

The DPU/ICU is based on a 20 MHz clock TEMIC TSC21020, that is a Digital Signal Processing (DSP) developed by Analogue Devices and implemented for flight use by TEMIC.

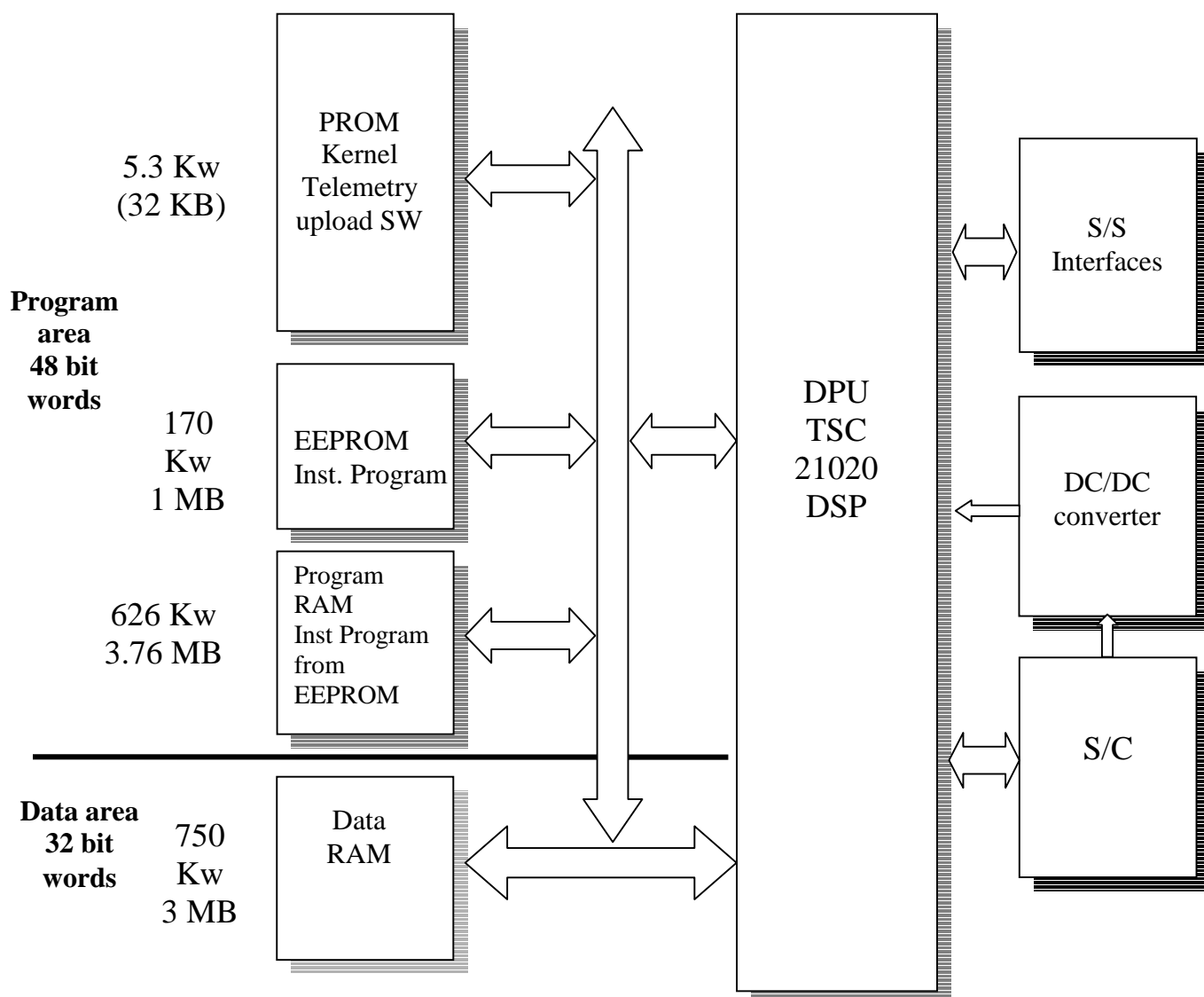
The DSP implements a Harvard architecture, i.e. the data bus (32 bit) and the programme bus (48 bit) are completely separated, so increasing the execution speed.

The program area is implemented with PROMs, EEPROMs and RAM. The PROMs store the initial boot loader and emergency recovery modules. The instrument program is stored in EEPROMs and copied in RAM at run time for execution. Program area may be used as data memory.

The DPU/ICU includes a synchronized DC/DC converter to supply internal circuitry, and supply FCU S/S in HIFI.

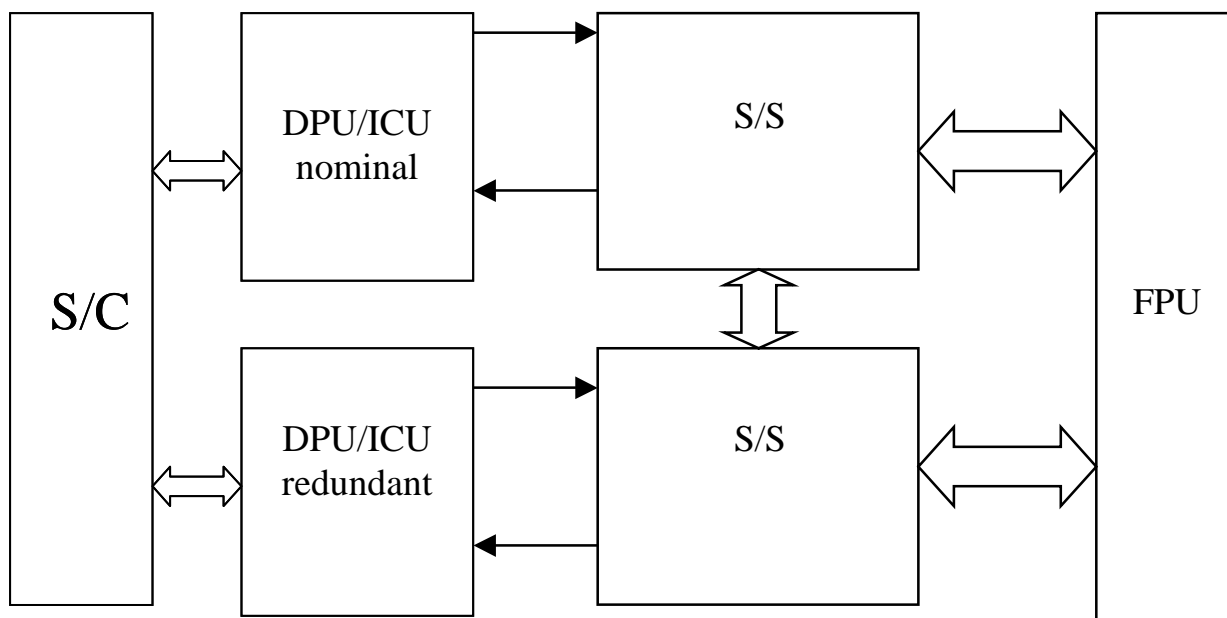
3.1 Overall DPU block diagram

The following diagram shows the main DPU blocks and the memory dimensions.



3.2 Redundancy concept

The top level DPU/ICU redundancy concept is shown in the following diagram:



The DPU/ICU box contains two complete units in cold redundancy states. The S/C nominal/redundant 28V power bus controls the switching between the two units.

4 Constraints

4.1 Calendar constraints

The main FIRST project constraints are [RD2]:

	PACS	HIFI	SPIRE
PDR			26 June 00
DDR	Sep 00	Sep 00	Sep 00
AVM delivery to consortium	Oct 01	Nov 01	Feb 02
CDR	Dec 02	Dec 02	Dec 02
AVM delivery to ESA	Apr 03	Apr 03	Apr 03
EQM delivery to consortium	May 02	June 02	Nov 02
PFM delivery to consortium	Sept 03	Oct 03	Mar 04
PFM delivery to ESA	Jul 04	Jul 04	Nov 04
FS delivery to consortium	NA	NA	NA
FS delivery to ESA	Dec 05	Dec 05	Dec 05
FIRST launch	2007	2007	2007

5 HW Work description

5.1 Development and model philosophy

The DPU electronic boards will be manufactured by CGSpace under a contract with ASI-IFSI. IFSI will design and manufacture the mechanical box, will integrate the electronic boards and perform all environmental tests.

The following units will be manufactured tested and delivered:

- AVM** This unit is electrically, mechanically and thermally representative of the flight unit, but without redundancy. It will use standard commercial components.
- EQM** This unit is electrically, mechanically and thermally representative of the flight unit, including redundancy. It will use the same components types of PFM at lower quality level. This unit will undergo the full qualification tests.
- PFM** This model is the flight unit. It will use flight standard components (baseline level SCC Level B for S/C I/F and level C for the rest TBC). This unit will undergo the acceptance tests.
- FS** These are just spare boards to be submitted to acceptance test. The FS boards are:
- 2 CPU/Memory boards
 - 1 DC/DC PACS-SPIRE
 - 1 DC/DC board HIFI
 - 1 S/S board HIFI-SPIRE
 - 1 S/S board PACS
 - 2 Motherboards

5.2 Verification plan

The verification plan must be compliant with the project verification plan [AD5-7, RD1] and must fulfil the DPU/ICU development needs.

Environmental tests will be performed at TBD facilities.

In the following table the environmental test matrix is presented, with:

- X = a real test is carried out
A = an Analysis is conducted
NA = Non Applicable

	AVM	EQM	PFM	FS
Mass mesasurement	NA	X	X	X
CoG measurement	NA	X		
Vibrations	NA	X	X	X
Thermal/Vacuum cycle	NA	X	X	X
Radiation tolerance	NA	NA	A(**)	A(**)
EMI / EMC	NA	X(*)	X(*)	A(*)

(*) : EMI/EMC tests should be carried out with subsystems.

(**) : The radiation tolerance is verified by analysis only, taking into account the materials involved.

5.3 Ground associated equipment

The ground equipments are used to develop and test one item without the presence of the others.

Only the equipments needed for DPU/ICU development are listed.

The simulators replace one or more items.

The tools are used to operate, check or integrate an item.

Most simulators are PC based as it is the most flexible and economical solution.

5.3.1 Simulators

Simulator	Used for...	Functions	Provided by
DRCU Simulator	...the control and monitoring of the SPIRE DPU during tests and commissioning	Replaces DRCU Receives commands and sends science and HK data	SPIRE project
MEC/DEC Simulator	...the control and monitoring of the PACS DPU during tests and commissioning.	Replaces PACS MEC/DEC Receives commands and sends HK data	PACS project
SPU Simulator	...the control and monitoring of the PACS DPU during tests and commissioning.	Replaces PACS SPU Receives commands and sends science and HK data	PACS project
HIFI S/S Simulator	...the control and monitoring of the HIFI ICU during tests and commissioning.	Replaces HIFI S/S interfaces	IFSI - HIFI project

5.3.2 Tools

Tool	Used for ...	Functions	Provided by
EGSE	... DPU/ICU SW development and testing	Simulates the S/C HW and SW I/F.	PACS-HIFI-SPIRE projects

6 SW Work description

In the following table the schedule of all the activities foreseen for the software development is reported.

WP	Description
1	OBS
1.1	Spacecraft I/F
1.2	Subsystem I/F
1.3	OBS Controller
1.4	Data Packetiser
1.5	Health autonomy modules
1.6	AVM issue
1.7	PFM issue
1.8	Documentation
1.9	Support Activities
1.9.1	Virtuoso OS
1.9.2	Test modules

There is one main WP (OBS), shortly described in the following. All the other work packages shall be considered as a breakdown of all the activities related to it. They are described in detail in the following sections.

Title: On Board Software (OBS)

Objectives:

To provide the computer board the functionality to manage the instrument.

WP description:

Development of the DPU/ICU OBS.

- Design activities: user requirements definition, logical model design, software requirements definition, architectural design. (WP 1.3, 1.8)
- Coding activities: detailed design and code development. (WP 1.3, 1.5, 1.8)
- Testing activities: unit tests, integration tests, acceptance tests. CDMS interface simulator development. Subsystems' interfaces simulators development. SVVP definition. Test reports generation. (WP 1.1, 1.2, 1.4, 1.6, 1.7, 1.8, 1.9)

6.1 Work Package 1.1 – Spacecraft I/F

Objective: to develop the software task dedicated to handle the interface between the DPU/ICU and the CDMS. This task will run in parallel to the other OBS tasks: the necessity of a dedicated task with these purposes is due to the fact that the CDMS interface will be compliant with the MIL-STD-1553B standard in which there is only one Bus Controller (the CDMS) and all the activities (in terms of telecommands reception/telemetry sending) are commanded/synchronised by it. The task will implement both the low level electrical interface protocol defined by the MIL-STD-1553B standard and the FIRST dedicated Transfer Layer Protocol (AD9) for managing the communications with the spacecraft.

WP description: This work package will be composed by the following activities:

- task design: logical decomposition
- task design: architectural design
- task design: detailed design-pseudocode
- code development: source C code
- software testing: unit tests
- software testing: integration tests

WP inputs: - OBS URD (draft, 01/01/2000)

- PS - ICD (01/06/2000)
- IID A (01/01/2000)
- IID B (01/01/2000)
- AD6 (01/06/2000)
- Development platform with: Axiomsys CASE tool
(01/01/2000) ADSP compatible development board
Virtuoso Operating system
C language development environment
MIL-STD-1553B compatible board
Configuration management tool
- Simulators of the other OBS components for the task interfaces testing
(output of WP 1.4) (when necessary, starting from 01/08/2000)

WP outputs

- Logical model: the sections relevant to this task (11-08-2000)
- Software specifications: the requirements relevant to this task
(11-08-2000)
- Architectural design: the sections relevant to this task (11-08-2000)
- Source code (02-04-2001)
- Executable files (either the single executable or the complete image of the OBS, depending
on the operating system implementation)
(AVM, PFM Issues)

6.2 Work Package 1.2 – Subsystems I/F

Objective: to develop all the software modules dedicated to handle the interfaces between the DPU/ICU and the instruments' subsystems. Even if this software will not be a separate task, the development of the functions dedicated to the subsystem interface handling needs to be included into a separate work package, essentially because of the additional instrument-specific software specifications they need, with respect to the overall requirements. Moreover the optimisation of the interface reading/writing performances will need dedicated subsystem simulators and test procedures.

WP description: This work package will be composed by the following activities:

- task design: logical decomposition
- task design: architectural design
- task design: detailed design-pseudocode
- code development: source C code
- software testing: unit tests
- software testing: integration tests

WP inputs:

- DPU/ICU to subsystems ICDs. (30/06/2000)
- OBS URD (draft, 01/01/2000)
- Operating modes/observing procedures detailed descriptions
- Development platform with: Axiomsys CASE tool
(01/01/2000) ADSP compatible development board
Virtuoso Operating system
C language development environment
Configuration management tool
- Subsystem I/F simulators HW (?)
- Simulators of the other OBS components for the functions interfaces
testing (output of WP 1.4) (when necessary, starting from 01/06/2000)

WP outputs

- Logical model: the sections relevant to this task (11-08-2000)
- Software specifications: the requirements relevant to this task
(11-08-2000)
- Architectural design: the sections relevant to this task (11-08-2000)
- Source code (02-04-2001)

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- Executable files (either the single executable or the complete image of the OBS, depending on the operating system implementation)
(AVM, PFM Issues)

6.3 Work Package 1.3 - OBS Controller

Objective: to develop the software task necessary to handle all the commands execution, that is all the activities necessary to the implementation of the instruments operating modes. This task is the core of the DPU/ICU OBS: it will be able to interpret the telecommands and to translate them into single instructions for the instrument. It will be interfaced with the Spacecraft Interface task and the Data Handling task via the standard interprocess communication protocols supported by the Virtuoso operating system: this will ease the task interface testing during the system integration activities.

WP description: This work package will be composed by the following activities:

- task design: logical decomposition
- task design: architectural design
- task design: detailed design-pseudocode
- code development: source C code
- software testing: unit tests
- software testing: integration tests

WP inputs:

- OBS URD (draft 01/01/2000)
- PS-ICD (01/06/2000)
- Operating modes/observing procedures detailed descriptions (01/06/2000)
- AD6 (01/08/2000)
- Development platform with: Axiomsys CASE tool
(01/01/2000)
 - ADSP compatible development board
 - ADSP C runtime library
 - Virtuoso Operating system
 - C language development environment
- Configuration management tool
- Simulators of the other OBS components for the task interfaces testing (output of WP 1.4) (when necessary, starting from 01/06/2000)

WP outputs

- Logical model: the sections relevant to this task (11-08-2000)
- Software specifications: the requirements relevant to this task (11-08-2000)
- Architectural design: the sections relevant to this task (11-08-2000)
- Source code (02-04-2001)
- Executable files (either the single executable or the complete image of the OBS, depending on the operating system implementation)
(AVM, PFM Issues)

6.4 Work Package 1.4 – Data packetiser

Objective: to develop the software task necessary to packetise the science/HK/event data according to the ESA telemetry standard and the FIRST packet utilisation standard.

WP description: This work package will be composed by the following activities:

- task design: logical decomposition
- task design: architectural design
- task design: detailed design-pseudocode
- code development: source C code
- software testing: unit tests

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- software testing: integration tests

WP inputs:

- FIRST/PLANCK Packet Structure Interface Control Document (01/07/2000)
- OBS URD (DRAFT FORM, 01/01/2000)
- Development platform with: Axiomsys CASE tool (01/01/2000)
 - ADSP compatible development board
 - ADSP C runtime library
 - Virtuoso Operating system
 - C language development environment
 - Configuration management tool
- Simulators of the other OBS components for the task interfaces testing (output of WP 1.4) (when necessary, starting from 01/06/2000)

WP outputs

- Logical model: the sections relevant to this task (11-08-2000)
- Software specifications: the requirements relevant to this task (11-08-2000)
- Architectural design: the sections relevant to this task (11-08-2000)
- Source code (02-04-2001)
- Executable files (either the single executable or the complete image of the OBS, depending on the operating system implementation) (AVM, PFM Issues)

6.5 Work Package 1.5 – Health Autonomy Functions

Objective: to develop all the software autonomy functions.

WP description: This work package will be composed by the following activities:

- task design: logical decomposition
- task design: architectural design
- task design: detailed design-pseudocode
- code development: source C code
- software testing: unit tests
- software testing: integration tests

WP inputs:

- OBS URD (draft, 01/01/2000)
- Autonomy functions specifications – requirements (01/09/2000)
- Development platform with: Axiomsys CASE tool (01/01/2000)
 - ADSP compatible development board
 - ADSP C runtime library
 - Virtuoso Operating system
 - C language development environment
 - Configuration management tool
- Simulators of the other OBS components for the functions interfaces testing (output of WP 1.4) (when necessary, starting from 01/06/2000)

WP outputs

- Logical model: the sections relevant to this task (11-08-2000)
- Software specifications: the requirements relevant to this task (11-08-2000)
- Architectural design: the sections relevant to this task (11-08-2000)
- Source code (07-05-2001)
- Executable files (either the single executable or the complete image of the OBS, depending on the operating system implementation) (AVM, PFM Issues)

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6.6 Work Package 1.6 – AVM Issue

Objective: to perform the AVM AIV procedure.

WP description: This work package will be composed by the following activities:

- to perform system integration tests
- to perform the in house acceptance tests with the Spacecraft and Subsystems simulators
- to perform the in house integrated (SW+HW) AVM acceptance tests with the EGSE and the Subsystems simulators
- to perform the AVM acceptance at the consortia premises.
- to provide test reports

WP inputs:

- OBS URD (draft, 01/01/2000)
- DPU/ICU OBS SVVP (draft available from 05/2001)
- EGSE (01/05/2001 - 01/07/2001)
- Subsystems simulators (01/05/2001) (PACS)
- Subsystems simulators (01/06/2001) (HIFI)
- Subsystems simulators (01/07/2001) (SPIRE)

WP outputs

- DPU/ICU AVM (20/10/2001) (PACS)
- DPU/ICU AVM (20/11/2001) (HIFI)
- DPU/ICU AVM (20/02/2002) (SPIRE)
- On site acceptance tests reports : (20/10/2001) (PACS)
(20/11/2001) (HIFI)
(01/07/2001) (SPIRE)

6.7 Work Package 1.7 – PFM Issue

Objective: to maintain the OBS until the PFM delivery.

WP description: This work package will be composed by the following activities:

- to update the OBS according to new specifications/requirements
- to execute all the tests necessary to verify and accept the implemented changes.

WP inputs:

- AVM package: OBS code and documentation (20/03/2002)
- new specifications (if any)
- Development platform with: ADSP compatible development board
ADSP C runtime library
Virtuoso Operating system
C language development environment
Configuration management tool

WP outputs

- Documentation updates (DDD mainly, other documents updates only if explicitly requested)
- Source code
- Executable files (either the single executable or the complete image of the OBS, depending on the operating system implementation)

6.8 Work Package 1.8 – Documentation

Objective: to provide all the documents necessary to support and describe the software development process.

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WP description: This work package will be composed by the following activities:

- To write/maintain all the deliverable documents (see section 3) in accordance to the ESA AD2, AD3 standards and to the document management indications provided by the three Consortia.
- To keep the deliverable documentation under configuration control.
- To write the non deliverable documents (technical notes/reports) requested by the Consortia as support to the OBS description/status understanding.

WP inputs:

- AD1, AD2, AD3
- All the applicable documents on which will be based the compilation of the user requirements (mainly: all AD4, the FIRST/PLANCK Operations Interface Requirements, Document, the FIRST/PLANCK Packet Structure Interface Control Document, FIRST Operations Scenario Document, the FIRST Instrument Commanding Concepts, all the documents describing the instruments operating modes) (starting from 01/09/1999)
- CASE tool outputs: logical model diagrams, architectural design diagrams, state transitions tables, data dictionary
- Test reports to be included into a OBS STD
- Configuration management tool

WP outputs

- OBS URD (draft, 01/01/2000; first issue ISVR, PDR)
- OBS SSD (draft , 01/07/2000; first issue IBDR/IHDR)
- OBS DDD (draft 01/07/2001; first issue ICDR)
- OBS SVVP (draft 01/05/2001; first issue ICDR)
- OBS User Manual (draft 01/06/2002, final version at PFM issue).

6.9 Work Package 1.9.1 – Support activities: Virtuoso OS

Objective: to install, analyse and evaluate the EONIC Virtuoso Operating System. In particular: to check with dedicated benchmarks the performances of the ADSP with the OS running on it and to analyse the way the OS linker creates the software images.

WP description: This work package will be composed by the following activities:

- participation to information/training courses/seminars on the Virtuoso OS.
- To install the OS on the ADSP PC board and to design and perform benchmarks for the VIRTUOSO evaluation
- To execute dedicated tests on the linker behaviour.

WP inputs:

- Development platform with: ADSP compatible development board (01/01/2000)
- ADSP C runtime library
- C language development environment
- Virtuoso Operating system (01/05/2000)

WP outputs:

- Final Virtuoso OS evaluation report (01/07/2000)

6.10 Work Package 1.9.2 – Support activities: Test Software

Objective: to develop all the software simulators/stubs necessary to perform the testing activities.

WP description: This work package will be composed by the following activities:

- code development: components stubs, simulators
- to provide test input data and, when possible, test expected results

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WP inputs:

- DPU/ICU OBS SSD (01/06/2000)
- Development platform with:
 - ADSP compatible development board
 - ADSP C runtime library
 - Virtuoso Operating system
 - C language development environment
 - Configuration management tool

WP outputs:

- test procedures/data to be included into the test reports

7 Development calendar

In the following table the DPU/ICU milestones are shown:

HW calendar

Description	PACS	HIFI	SPIRE
AVM boards to IFSI (from CGSpace)	Apr 01	May 01	Jun 01
EGSE delivery to IFSI (1 unit, 3 SW)	May 01	Jun 01	Jul 01
PACS S/S simulators	May 01	-	-
HIFI S/S simulators	-	Jun 01	-
SPIRE DRCU simulator	-	-	Jul 01
AVM delivery to consortium	Oct 01	Nov 01	Feb 02
Authorization to proceed	Aug 01	Sep 01	Oct 01
EQM boards to IFSI (from CGSpace)	Nov 01	Dec 01	Jan 02
EQM environmental tests	Apr 02	May 02	Oct 02
EQM delivery to consortium	May 02	Jun 02	Nov 02
Authorization to proceed	Sep 02	Sep 02	Sep 02
PFM boards to IFSI (from CGSpace)	Mar 03	Apr 03	May 03
PFM environmental tests	Aug 03	Sep 03	Feb 04
PFM delivery to consortium	Sep 03	Oct 03	Mar 04
FS boards to IFSI (from CGSpace)	Jun 03	Jun 03	Jun 03
FS environmental tests	Apr 04	Apr 04	Apr 04
FS delivery to consortium	NA	NA	NA

SW calendar

Description	PACS	HIFI	SPIRE
AVM issue	Oct 01	Nov 01	Feb 02
PFM issue	Sep 03	Oct 03	Mar 04
Documentation	at PFM issue	at PFM issue	at PFM issue

8 Description of deliverables

8.1 Deliverable models

The FTS warm electronics cards are delivered to CEA.

Model per consortium	Flight representativity	Difference with flight	Deliverables
AVM	Dimensions, interface, functions	No redundancy, commercial components (TBC)	3
AVM SW	Preliminary version	Upgradable to flight	3
EQM	Dimensions, interface, functions	Full redundancy, FFF* components (TBC)	3
EQM SW	Upgraded AVM SW	Upgradable to flight	3
PFM	100%	None	3
PFM SW	100%	None	3
FS	100%	None	Boards

*: as far as possible commercial components within Fit-Form-Function wrt flight components

9 Schedule

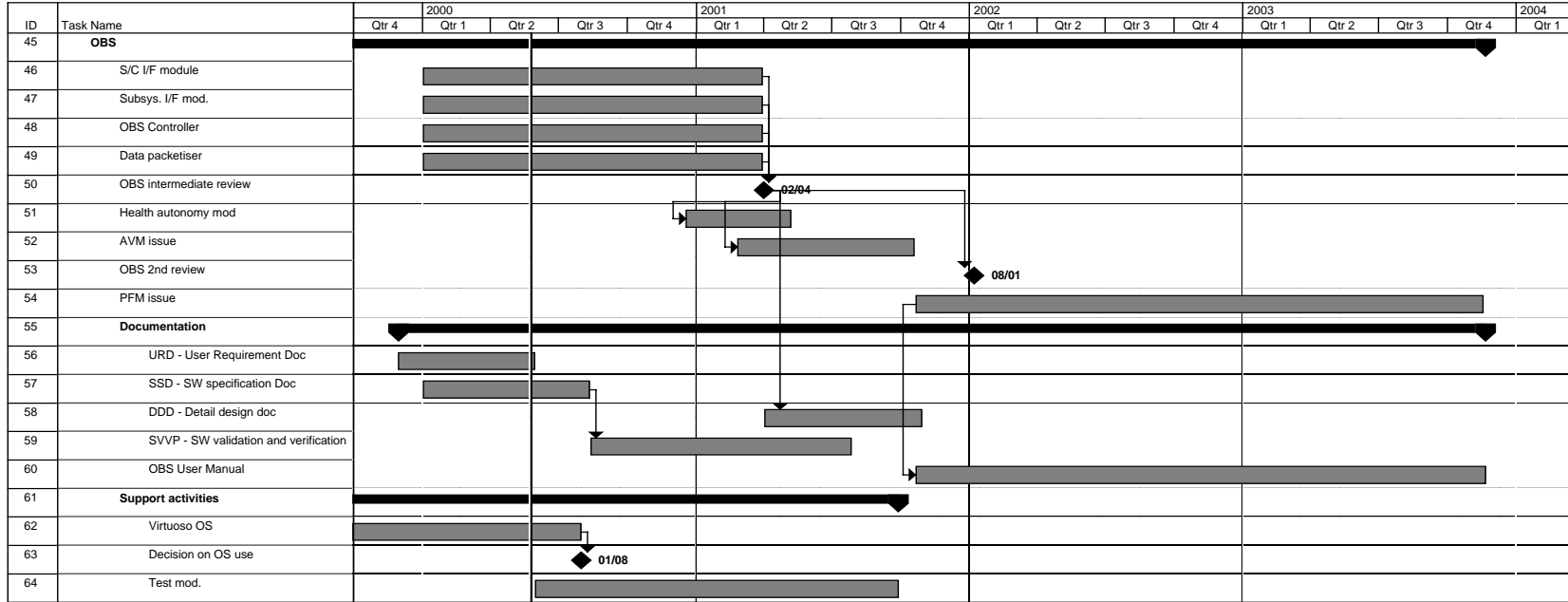
9.1 PACS





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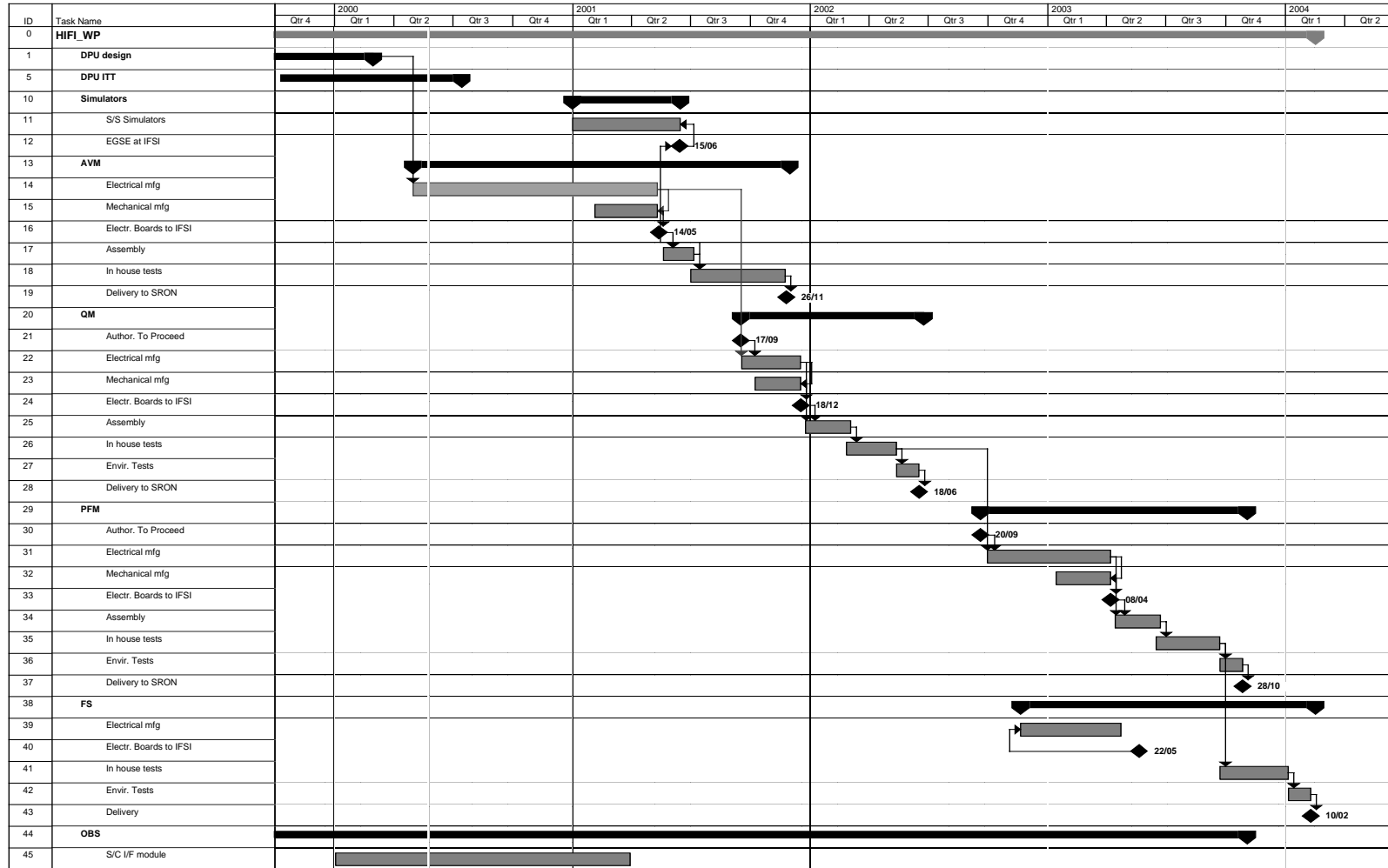




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9.2 HIFI





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9.3 SPIRE

