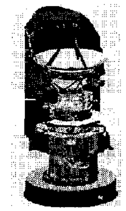


FIRST/Planck

Commonality Working Group #4

Instrument Operations and and On-Board Software

Meeting #1

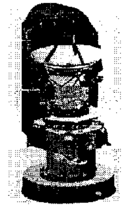
ESTEC, 10 February 1999

P. Estaria (SCI-PT)

WORKING GROUP MEMBERS

10.02.1999

WG #	ESA Chair	ESA Secretary	Planck HFI	Planck LFI	FIRST HIFI	FIRST PACS	FIRST SPIRE	Cross Instrument Support
SC	T. Passvogel	P. Estaria	J. Charra	C. Butler	H. Aarts	O. Bauer	K. King	
1/2	F. Vandenbussche	H. Schaap	R. Pons J.L. Beney	NN	D. Beintema	E. Renotte	V. Mauguen M. Carter	R. Orfei R. Cerulli J.H. Herreros
3	A. Heras	No permanent Secretary	R. Gispert F. Couchot	C. Butler	P. Roelfsema	O. Bauer E. Wiezorrek	T. Dimbylow R. Gastaud	P. Estaria A. di Giorgio
4	F. Vandenbussche	P. Estaria	J. Charra F. Couchot	C. Butler TBD (Laben)	P. Roelfsema	H. Feuchtgruber	D. Pike NN (Sap)	R. Cerulli
5	P. Estaria	H. Schaap	R. Gispert F. Pajot	TBD (Laben)	P. Roelfsema S. Pezzuto	H. Feuchtgruber	NN	
6	P. Claes	NN (G. Pilbratt J. Tauber K. Bennet)	R. Gispert	F. Pasian	P. Roelfsema	O. Bauer R. Huygen	T. Dimbylow N. Todd	P. Estaria P. Andreani



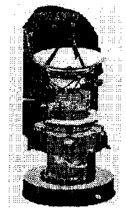
Agenda (1)

1. Introduction (ESA)

2. Short verbal report on main outcome of FINDAS-IDIS and RTA/QLA CWGs meetings (ESA)

3. CWG # 4 Terms of Reference
   - refine role and objectives (based on Refs. 2 and 3 above)
   - establish (review/update/agree) list of tasks (based on Refs. 2 and 3 above)
   - identification of (short term) objectives for the ITT release.

4. Current status of DPU and SPU developments (about 15 mins per Instrument)
   - LFI - HFI - HIFI - PACS - SPIRE



Agenda (2)

5. Preliminary ideas: overall testing philosophy (bench level --> instrument level --> system tests) (about 10 mins per Instrument)
   - LFI - HFI - HIFI - PACS - SPIRE

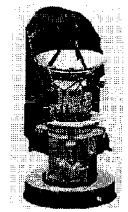
6. Preliminary identification (or confirmation) of common items
   - DPU and SPU items (H/W and S/W)
   - overall -common- testing philosophy

7. Prioritisation of CWG tasks

8. (Detailed) plan of CWG activities for the next 6 months (1 year ?)

9. Date and place of next meeting(s)

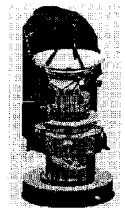
10. A.O.B.



Summary: Overall allocation of responsibilities

DPUs			SPUs		
SPIRE	H/W L-L S/W H-L S/W	IFSI	**SPIRE**	H/W L-L S/W H-L S/W	IAC IAC CEA-Sap, Saclay
PACS	H/W L-L S/W H-L S/W	IFSI	**PACS**	H/W L-L S/W H-L S/W	IAC IAC T.U. Wien
HIFI	H/W L-L S/W H-L S/W	IFSI IFSI CESR, Toulouse	**HIFI**		No SPU
LFI	H/W L-L S/W H-L S/W	IAC	**LFI**	H/W L-L S/W H-L S/W	IAC
HFI	H/W L-L S/W H-L S/W	IN2P3-LAL Orsay	**HFI**		No SPU

esa **FIRST/Planck**



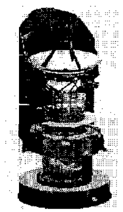
Commonality Working Group #4

Kick-Off: January 1999

End: AVM delivery: January 2003

Main Tasks:

- ~~Define Task allocation between DPU and SPU (SPIRE, PACS, LFI)~~
- ~~Define DPU-SPU H/W and S/W Interfaces (WG#2)~~
- Identify S/C-related services required (OTF, pointing, other.. (WG#2)
- ~~Define~~ SPU low-level and high-level "common" functions
- ~~Define~~ DPU low-level and high-level "common" functions
- Define Autonomy requirements/functions - "common"
- Define Autonomy requirements/functions - instrument specific
- Define Commanding Scheme
- Define Memory load/dump / verify scheme
- Define common scheme for TM & TC packet definition (WG #3)



Commonality Working Group #4

Main Tasks (cont'd): — timescales? – need input from previous subjects

- Review "common" URDs
- ~~Monitor on-board S/W implementation~~
- ~~Define & supervise Acceptance Tests~~

Initial Inputs required:

- OIRD
- Status Report IFSI
- Status Report IAC

Problems: Group membership should be expanded

- ~~CESR, Toulouse (HIFI; DP~~U)
- IAC (LFI; DPU & SPU)
- CEA-Sap (SPIRE; SPU) ? needs?
- T.U. Wien (PACS; SPU)
- ESOC (MOC)

Commonality Working Group #5

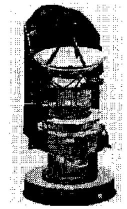
Kick-Off: Mid-2000

End: December 2006 (Ground Segment Readiness Review)

Main Tasks (short to medium term):

(4)

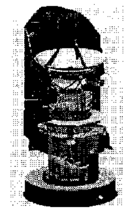
- Define overall testing philosophy (bench level → Instrument Level → System Tests → Commissioning → PV → Routine)
- Define "common" symbolic Instrument Control Language (ISO-based ?) + Translator
- Define "common" (H/W and S/W) interfaces between Testing Facilities and EGSE (WG #2)
- Define "common" interfaces with FINDAS/IDIS (WG #6)
- Test and Operations Language definition? (Rosetta? EGSE Contractor)



CWG #4 - K.O. meeting 10 February 1999

OIRD (Operations Interface Requirement Document)

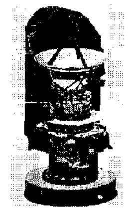
- Draft 1 - August '97 - Released with FIRST/Planck AO - 30 September 1997
- Produced by ESOC
- Generic document: covers spacecraft and payload
- Review/update cycle with ESOC: March - April 1999
- Based on PUS (Packet Utilisation Standard)
- Covers (spacecraft and instrument)
    - operability
    - autonomy
    - definition/function of TM/TC packets



CWG #4 - K.O. meeting 10 February 1999

OIRD (Operations Interface Requirement Document) - continued

- Based on "merger" concept
- Needs to be updated into:
  - FIRST OIRD
  - Planck OIRD
- Goal: simple and safe Flight Operations Procedures
- Sequencing of data
  - S/C and Instrument Housekeeping
  - Operational events and anomaly logs
  - Science TM



CWG #4 - K.O. meeting 10 February 1999

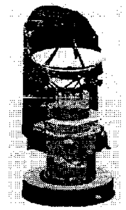
OIRD (Operations Interface Requirement Document) - continued

Terminology

- **AP** (Application Process): S/W task that perform one or more pre-determined complex functions which are part of the basic on-board application S/W.

  Example:

  - Data acquisition
  - TM packet management
  - TC packet management
  - Data Storage Management



CWG #4 - K.O. meeting 10 February 1999

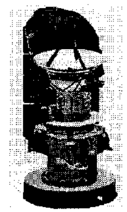
OIRD (Operations Interface Requirement Document) - continued

Terminology

- **OBCP** (On-Board Control Procedures): S/W task that can be loaded and executed on-board and interacts with the rest of the on-board application S/W.

  Example:

  - Execute and verify a TC to a subsystem
  - React to on-board detected malfunction (e.g. called by monitoring process)
  - Coded in Spacecraft Control Language (SCL) = simple !

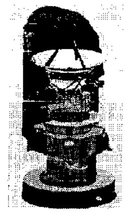


CWG #4 - K.O. meeting 10 February 1999

OIRD (Operations Interface Requirement Document) - continued

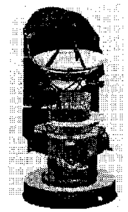
Comments received

• **SPIRE:**		12.09.97	(King)
• **PACS:**			(Bauer)
• **HIFI:**	(due)	15.02.99	(Aarts)
• **HFI**		25.11.98	(Charra)
• **LFI**		21.12.98	(Butler)



(Instrument) Manual Commanding

- All commanding via IFOP (Instrument Flight Operations Procedures)
- Much manual commanding during commissioning phase
- No direct commanding from FSC, ICCs, DPCs
- Command Requests FSC, ICCs, DPCs --> to MOC possible
- Examples:
  - on-board schedule control? (TBD)
  - change in instrument TM allocation table?
  - change in instrument configuration
- Commanding to instruments which are not prime should not be forbidden (TBC)
- Permanent Command Sequences (PCSs) - in already translated form (binary) - should be available at the MOC



Instrument Command Verification Scheme

- Planck
  - Few commands to instruments
  - Simple to verify
- FIRST
  - Many commands
  - Complex to verify
- MOC performs 3 levels of command verification
  - Level 1: PTV: Pre-Transmission Validation
  - Level 2: CTV: Command Transmission Verification
  - Level 3: CEV: Command Execution Verification (not for instruments)
- Need to check with SCOS 2000 (Packet standard)
- For the MOC each instrument is a subsystem identified by a single alphabetic character (e.g. Lxxx xxx (LFI)

Appendix - Subsystem On-Board Software

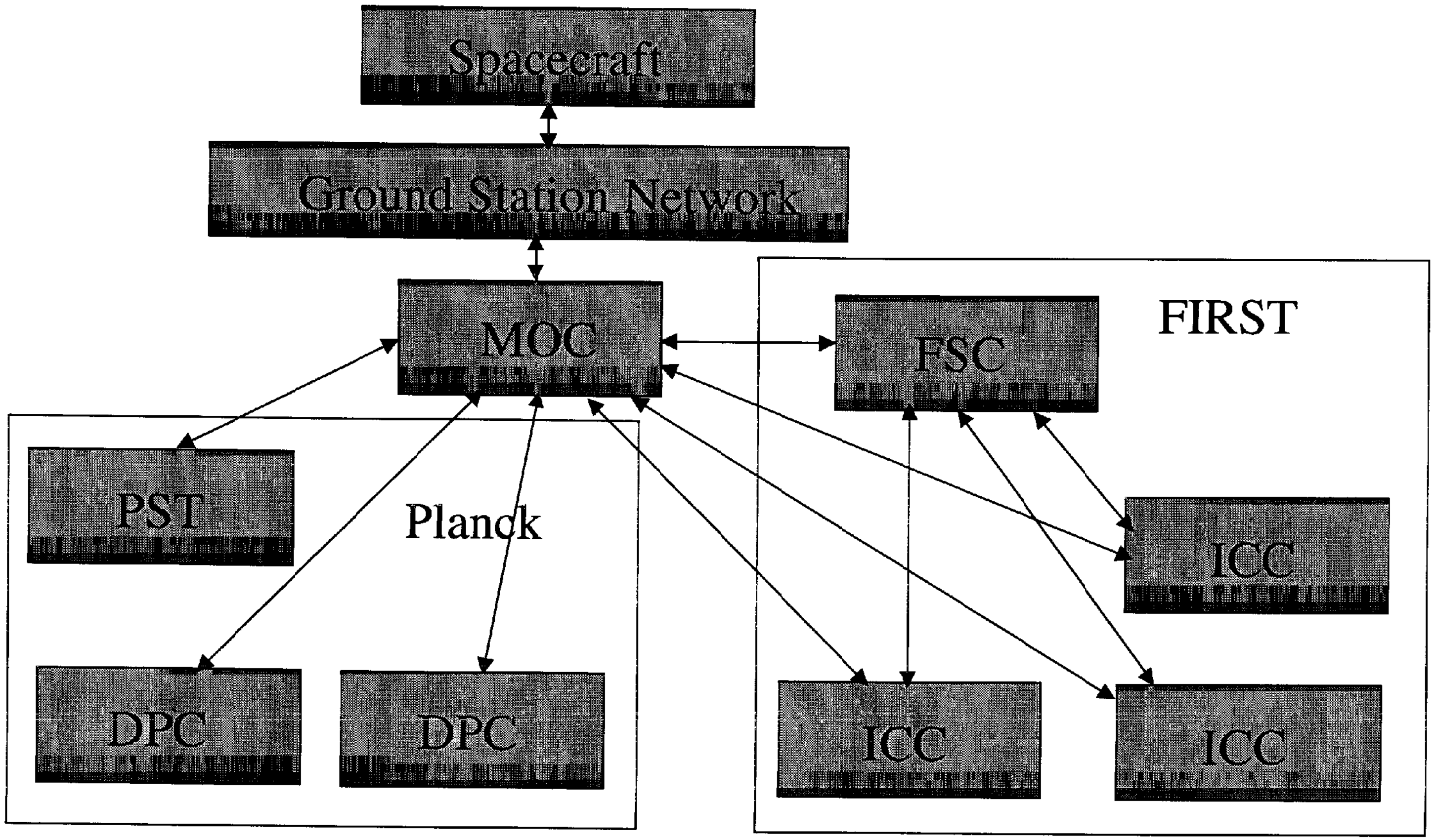
- Provide a breakdown of each subsystem memory showing RAM and ROM address areas, areas allocated for program code, buffer space and working parameters (e.g. content of protected memory)
- Provide a word by word listing of program code
- Provide a word by word listing of all software data areas (referencing the software parameter reference number, and mnemonics)
- Provide on-board Software Development Environment description (SDE) and SDE Users Manual
- Provide on-board Software Validation Facility (SVF) description and SVF Users Manual

Mission Operations Scenario

John Dodsworth TOS/OFC
Pierre Estaria SCI/PT

10 Feb. 1999

Ground Segment



Ground Segment

- FIRST
  - First Science Centre
    - Observation Planning
  - Instrument Control centres
    - Instrument monitoring and control
- Planck
  - Planck Science Centre
    - Observation Planning/ Instrument Configuration
    - Data Centres
      - Data analysis

Ground Segment

- MOC
  - Mission Planning/ Ground Segment scheduling
  - Spacecraft Monitoring and Control
  - Data Distribution (to FINDAS)
- FINDAS
  - Interface between MOC and Science ground segment
  - science repository etc.

Ground Segment

- Routine Operations Ground Station
  - Perth 34m Antenna (Shared with Rosetta)
- LEOP/ Commissioning/ PV
  - Perth
  - Kourou (shared with XMM)
  - Villafranca

Operational Principles

- Principles:
  - all operations pre-planned
  - on-board schedule driven operations
  - no Real Time science except in special cases: commissioning / Performance Verification
  - data stored at the ground station and transferred to ESOC at lower than received rate.

Operations

Consequences on the spacecraft design:

- Subsystems and Instruments have to be intrinsically “safe”: anomalies have to be recognized and corrected locally if possible;
- non-correctable anomalies have to be notified to the OBDH for safing actions;
- local problems should not propagate to higher levels;
- status/configuration of the subsystem/instrument has to be completely available in Housekeeping Telemetry ;
- history of the operations has to be maintained for quick access:
  - TC history, event logging, exception logging, telemetry records;
- data system design has to allow intelligent retrieval mechanisms (e.g. separate VC for RT science data, RT HK data, event data, Historical science data, historical HK data, Memory dump data etc.

Data System design trade-off

- Science data rate should be high
- Data rates should be compatible with ground segment equipment (ca. 2.5 Mbps)
- Occupancy of the ground station should be low (sharing between FIRST, Planck, Rosetta)
- Data transfer rates should be low for cost reasons
- Data transfer rates should be high to ensure complete transfer before the next pass

FIRST/Planck Data System trade-off table

s/c data rate/ kbps	48 hr SSR capacity /Gbits	1hour down link data rate/kbps	2 hour down link data rate/kbps	3 hour down link data rate/kbps	4 hour down link data rate/kbps	Data Rate to MCC/ kbps/12hr	Data Rate to MCC/ kbps/16hr	Data Rate to MCC/ kbps/20hr	Line Capacity/ kbps
40	7	960	480	320	240	120	80	72	
60	10	1440	720	480	360	180	120	108	128
80	14	1920	960	640	480	240	160	144	
100	17	2400	1200	800	600	300	200	180	
120	21	2880	1440	960	720	360	239	216	256
140	24	3360	1680	1120	840	420	279	252	
160	28	3840	1920	1280	960	480	319	288	
180	31	4320	2160	1440	1080	540	359	324	
200	35	4800	2400	1600	1200	600	399	360	
220	38	5280	2640	1760	1320	660	439	396	512
240	41	5760	2880	1920	1440	720	479	432	
260	45	6240	3120	2080	1560	780	519	468	
280	48	6720	3360	2240	1680	840	559	504	
300	52	7200	3600	2400	1800	900	599	540	
320	55	7680	3840	2560	1920	960	638	576	
340	59	8160	4080	2720	2040	1020	678	612	
360	62	8640	4320	2880	2160	1080	718	648	
380	66	9120	4560	3040	2280	1140	758	684	
400	69	9600	4800	3200	2400	1200	798	720	
420	73	10080	5040	3360	2520	1260	838	756	1024
440	76	10560	5280	3520	2640	1320	878	792	
460	79	11040	5520	3680	2760	1380	918	828	
480	83	11520	5760	3840	2880	1440	958	864	
500	86	12000	6000	4000	3000	1500	998	900	
520	90	12480	6240	4160	3120	1560	1037	936	
540	93	12960	6480	4320	3240	1620	1077	972	
560	97	13440	6720	4480	3360	1680	1117	1008	
580	100	13920	6960	4640	3480	1740	1157	1044	
600	104	14400	7200	4800	3600	1800	1197	1080	

feasible rates

Communication Costs

Rate /Kbps	Line Cost/ month	FIRST mission/KECU	Planck mission/KECU
128	16.6KECU	730	400
256	31.2KECU	1.37K	750
512	53KECU	2.3K	1.3K
1000	81.6KECU	3.6K	2K

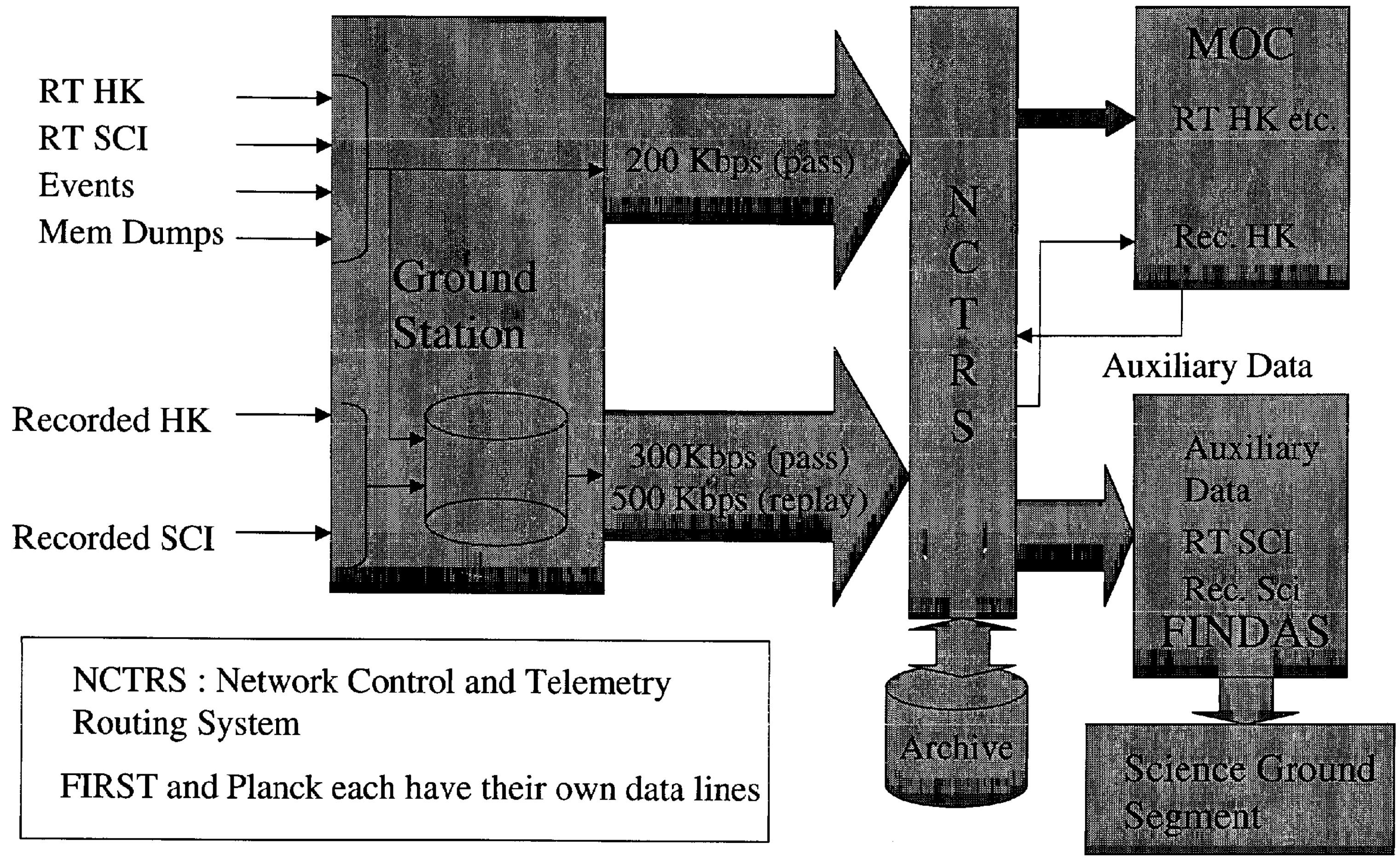
Probably 30% less in 2007

Possible Configuration

- S/c data rate 200kbps
- Recorder 35 Gbit
- Downlink rate 2.4 Mbps (2hrs)
- Data line 512 kbps
- Transfer time to OCC < 16hr.

MOC

Data flow model



Data flow model

- RT and dump Housekeeping data routed to Mission Control System
- All RT and Dump Data to Archive
- RT Science to user WS (principally for commissioning and PV) (via FINDAS?)
- Auxiliary data to archive
- Access to archive via FINDAS

Conclusion

Assuming good S/C data handling system design

- Science data available in Near Real Time for about 2 hours per day (assuming adequate FINDAS performance and good archiving scheme)
- Recorded data available within 16 hours of the start of the pass (oldest data ca. 38 hours old).

FIRST/PLANCK CWG #4
ESA/ESTEC 10/2/99

LFI

TEST PHILOSOPHY (PRELIMINARY)

BYCHRIS BUTLER (LFI INSTRUMENT PM

OVERALL TEST PHILOSOPHY

- PROTOTYPING WITH ELEGANT BREAD BOARD OF RADIOMETER CHAINS (30/40/70/100 GHZ):-
  - FRONT END UNITS, WAVEGUIDES, BACKEND UNITS

  FOR SCIENTIFIC PERFORMANCE VERIFICATION

- ELECTRICAL INTERFACES + PARTIAL FUNCTIONAL QUALIFICATION WITH AVM
- INSTRUMENT QUALIFICATION TESTING FOR CQM
- INSTRUMENT FM/PFM TESTING FOR PFM

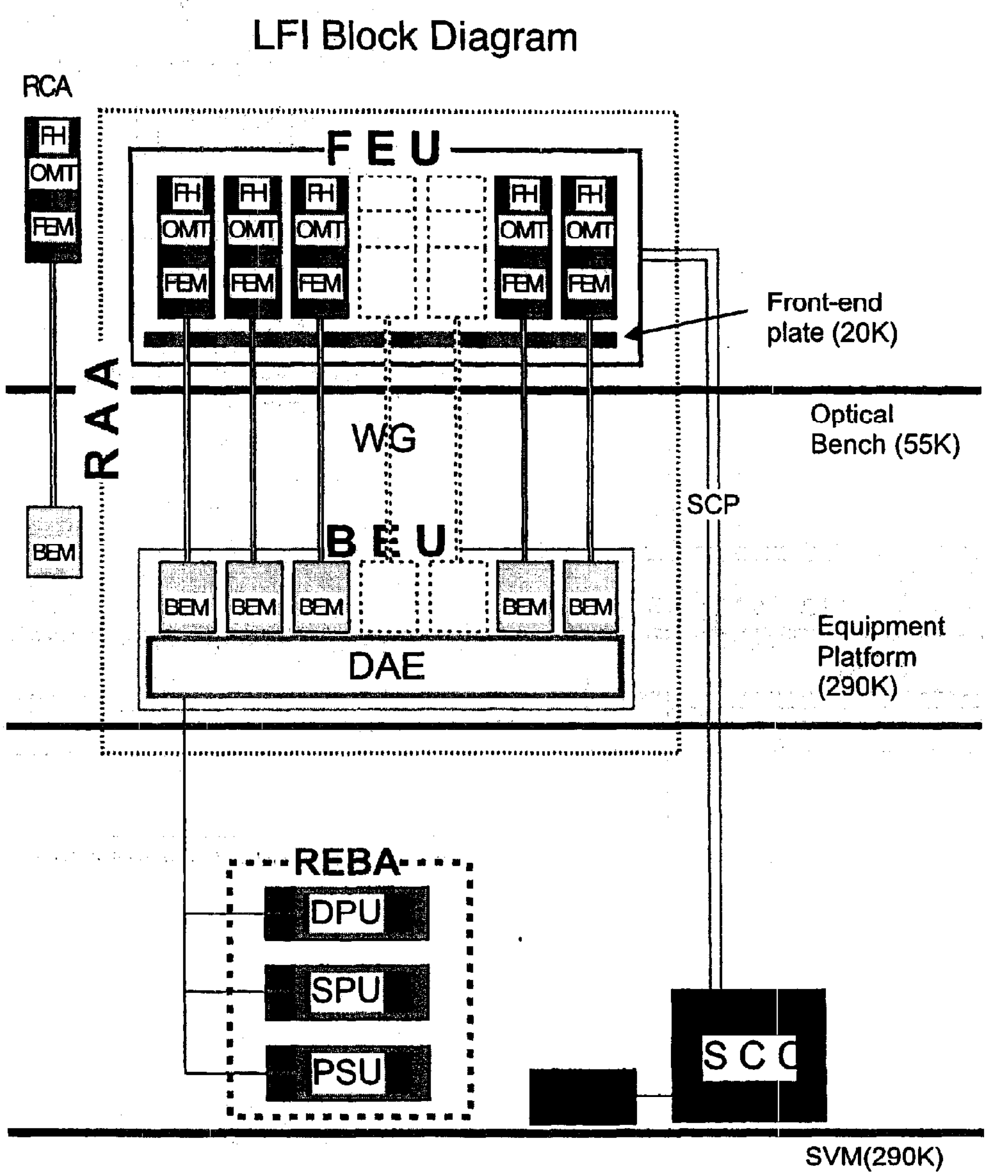


Figure 3.1: LFI block diagram.

INSTRUMENT AVM

- UNIT LEVEL AVM TESTING
  - ELECTRICAL INTERFACES/FUNCTIONALITY+SOFTWARE
    - AVM REBA
    - AVM BEU
    - AVM FEU
    - SORPTION COOLER SIMULATOR

- INSTRUMENT AVM TESTING
  - ELECTRICAI/F, AND ELECTRICAL/SOFTWARE/COMMUNICATION FUNCTION AND PERFORMANCE TESTS

INSTRUMENT CQM

- FOR RADIOMETER CHAINS
  - QUALIFICATION TESTING SINGLE PARTS AND MODULES OF EACH CHAIN TYPE (ELEC/VIB/TVT)

- UNIT LEVEL QUAL. TESTING
  - SORPTION COOLER + REBA (VIB/EMC/TVT)
  - FEU +BEU (ONLY VIB) - W. GUIDES TBD

- INSTRUMENT LEVEL
  - RAA (UNIT) TVT
  - ELECTRICAL AND FUNCTIONAL PERFORMANCE

  \+ EMC

CQM SYSTEM TESTS

- LFI INCOMING TEST
- INTEGRATION AND ALIGNMENT IN PPLM
- LFI FUNCTIONAL TEST (ASSUME EQUIV. TO ISST)
- QUAL. VIBRATION TEST
- LFI ISST
- QUAL. ACOUSTIC TEST
- LFI ISST
- QUAL. CONDUCTIVE EMC
- QUAL. THERMAL VAC. TESTS

• ALL TESTS DONE IN INSTRUMENT “STAND ALONE” CONFIGURATION AS SYSTEM EGSE MISSING

INSTRUMENT PFM

- RADIOMETER CHAINS
  - FM TESTING ON SINGLE PARTS AND MODULES OF ALL CHAINS (ELEC/VIB/TVT)
- UNIT LEVEL FM TESTING
  - SORPTION COOLER + REBA (VIB/EMC/TVT)
  - FEU + BEU (ONLY VIB)   - W. GUIDES TBD
- INSTRUMENT LEVEL
  - RAA (UNIT) TVT
  - ELECTRICAL AND FUNCTIONAL PERFORMANCE TESTING + EMC

PFM SYSTEM TESTS

- LFI INCOMING TEST
- INTEGRATION AND ALIGNMENT IN PPLM
- LFI ISST (STAND ALONE)
- INTEGRATION TO PLANCK SVM
- LFI ISST/IST/SVT (1)
- PFM SYSTEM VIB.+ACOUSTIC (LFI ISST/IST's)
- PFM EMC (CONDUCTIVE)
- PFM THERMAL VAC. AND THERMAL BALANCE
- SVT (2)
- FIRST/PLANCK CARRIER INTEGRATION
- CARRIER VIB.+ACOUSTIC+CLAMPBAND SHOCK

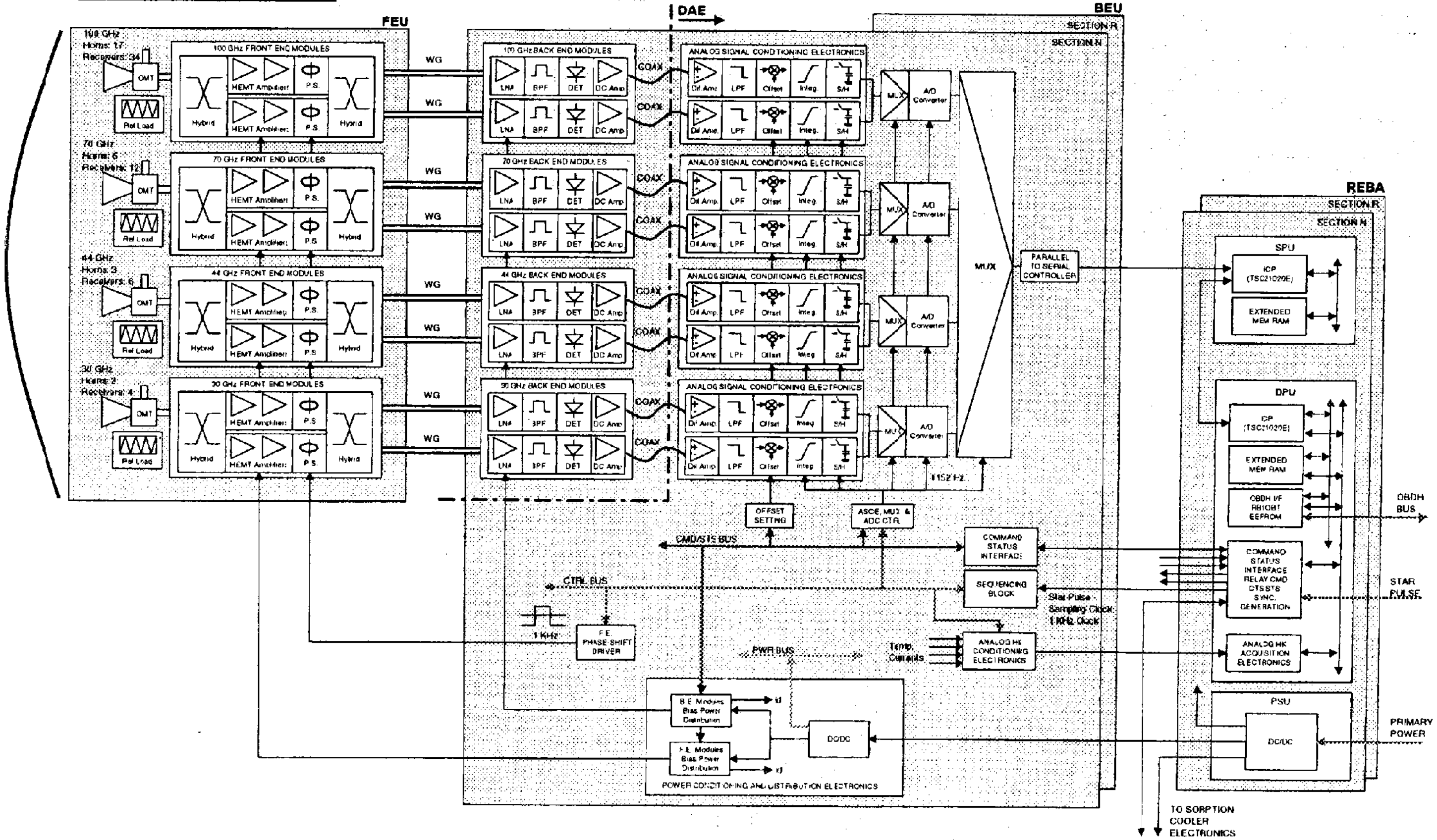
FIRST/PLANCK CWG #4
ESA/ESTEC 10/2/99

LFI

DPU AND SPU CURRENT TECHNICAL STATUS

BYCHRIS BUTLER (LFI INSTRUMENT PM)

LFI ELECTRONICS BLOCK DIAGRAM



LFI DPU SPU 1/2

- DPU AND SPU HOUSED IN THE RADIOMETER ELECTRONICS BOX ASSEMBLY (REBA)
  - REBA IS A SINGLE UNIT WITH COMPLETE COLD INTERNAL REDUNDANCY (SPU/DPU/PSU)

- DPU AND SPU PROCESSORS
  - uP 21020 (ANALOGUE DEVICES)
    - FLIGHT VERSION FROM TEMIC
  - "C" LANGUAGE AS BASELINE

LFI DPU SPU 2/2

- DPU/SPU MEMORY CHOICE NOT MADE YET

- DPU <> SPU BASELINE BUS CHOICE IS .-

  - IEEE 1355 FOR USING HIGH DATA RATE CHIP

    - SMVS 332 TEMIC - RAD TOLERANT (50 KRAD)

- DAE > SPU BUS AS ABOVE