FIRST/PLANCK

INSTRUMENT INTERFACE DOCUMENT

PART B

INSTRUMENT "PHC"

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Approval	
FOR INSTRUMENT : --	FOR ESA: -- Dr. Th. Paßvogel FIRST Payload System Manager ESA/ESTEC, Noordwijk

DOCUMENT CHANGE RECORD

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Draft	May 1996		All (First Working Draft)
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Draft 2	27 August 1997		Only chapter 1 and 3.

DISTRIBUTION LIST

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1. INTRODUCTION

The purpose of the Instrument Interface Documents (IIDs) is to define and control the overall interface between each of the FIRST/PLANCK scientific instruments and the FIRST/PLANCK spacecraft.
The IIDs consist of two parts, IID-A and IID-B.
Spacecraft performances, capabilities and requirements imposed on the instruments are described in part A of the documents, whilst instrument requirements on the spacecraft as well as instrument capabilities and performances are described in part B. The IID-B is in fact the successor to the Payload Definition Document (PDD)
There is one part A and there are just as many parts B, as there are instruments.

The IIDs are living documents.
The ESA Project team is responsible for updating and distributing the parts B. Updating takes place at regular intervals as a result of discussions and in agreement with the instrument teams.
As for the part A, after the initial issue by the ESA Project team it will be handed-over to the Contractor, who will take care of further updates and distribution.
Both IID-A and the IID-Bs will be part of the AO.

Chapter 4 of each of the IID-B documents consists of two parts.

The first part, from para 4 up to and including para 4.6.5 is devoted to descriptive information and background data necessary to enable a full and mutual understanding of the interface constraints between the spacecraft and instruments. This part is not to be considered as containing any requirement whatsoever, nor to imply any particular interpretation or meaning other than the one explicitly stated in the other chapters of this document and is therefore not applicable in any contractual sense.

The second part from para 4.7 onwards contains information relative to the scientific performance of the instrument. This part is to be considered as containing information which needs to be verified by test, analysis or a combination of the two and shall serve the purpose of demonstrating that the instrument will operate as intended for the particular mission.
Para 9.5 "Scientific Performance Verification" of the IIDs provides more information on this subject.

The IIDs will not cover any of the interfaces of the Instrument Control Centres (ICCs), the Data Processing Centres (DPCs) or the FIRST Science Centre (FSC)

2. APPLICABLE/REFERENCE DOCUMENTS

2.1 APPLICABLE DOCUMENTS

2.2 REFERENCE DOCUMENTS

3. KEY PERSONNEL AND RESPONSIBILITIES

3.1 KEY PERSONNEL

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3.2 RESPONSIBILITIES

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NAME	RESPONSIBILITY	TELEPHONE FAX EMAIL	ADDRESS

4. INSTRUMENT DESCRIPTION

4.1 INTRODUCTION

Direct detection with a photoconductor is a process where the incoming photons excite charge carriers into the conduction or valence band. A bias voltage across the photoconductor then causes a current to flow which is proportional to the input photon rate, i.e. power. The sensitivity is limited by detector thermal noise, detector shot noise, noise in the signal source and telescope thermal emission. With current detector technology the main limiting factor for direct detection with FIRST would be the telescope thermal background and its fluctuations.

In the foreseen FIRST environment the direct detection method is more efficient than heterodyne detection approximately for spectral resolving powers R (= $\nu/\delta\nu$ = $\lambda/\delta\lambda$) less than 3 x 10^3 for wavelengths shorter than 300 μm. Arrays of detectors are more easily implemented using these types of detectors. An exact comparison with heterodyne spectrometers is impossible because the spatial vs. spectral multiplex advantage depends on the individual astronomical source, but the main strength of direct detection instruments is imaging at low to medium spectral resolution.

Grating spectrometers provide the highest transmission which can be twice that of Fabry-Pérot (F-P) interferometer systems. In connection with a detector array they also allow for spectral multiplexing.
One advantage in this concept is that the source velocity can be unknown at the time of the observation. A great disadvantage, however, is the very uneconomic use of the array because the detectable lines are very sparsely distributed over the covered wavelength range.

Another approach for the spectroscopic mode seems, therefore, more appropriate which provides 2-dimensional, spatial mapping over a reduced field of view and, simultaneously, some spectral multiplexing to cover the velocity distribution in, e.g. a cluster of galaxies, and, in any case, to observe a spectral line with good baseline coverage on both sides of the line.
We will describe an instrument to perform spectroscopy and continuum measurements (photometry) over the 85-210μm range, using a photoconductive detector array and an image slicer in connection with a long-slit grating spectrograph.

4.2 SCIENTIFIC RATIONALE

The far infrared wavelength region contains a large number of spectral lines from abundant atoms, ions and molecules. These lines probe a wide range of excitation and ionization stages. They provide detailed information on density, temperature, velocities and abundances of ionized and neutral components of interstellar and circumstellar gas. High angular and spectral resolution measurements and accurate spatial mapping of these lines are necessary for determining the spatial distribution and kinematics. The astronomical objects for far infrared line spectroscopy range from nearby molecular clouds and star formation regions to active galactic nuclei, extra luminous galaxies and quasars. In addition, for most of the mentioned objects their continuum emission is of particular scientific value and interest in the whole of the submillimetre and far infrared region.

4.3 OVERALL CAPABILITIES

The PHC receiver is designed to provide imaging and spectroscopy in the region 85-210 μm. A 16 x 25 array of stressed Ge:Ga photoconductive detectors, nominally operating at 1.7 K is used.

The PHC can operate in two modes, which are characterised by the spectral resolution, R:

1. Medium resolution spectroscopy: $R = 1\text{-}3 \times 10^3$

2. Broad-band photometry: R = approx 2.3

4.4 HARDWARE DESCRIPTION

The PHC instrument consists of:

1. A cold focal-plane unit, containing optics at approximately 15 K, 4 K and a detector array at approximately 1.7 K with cryogenic readout electronics. Cooling at 15 K and 4 K is provided by the spacecraft, and the 1.7 K temperature is provided by connection to the superfluid helium cryogen tank.

3. Three warm electronics boxes located in the service module (SVM) at 300 K (nominal temperature):

   (I) Two analogue electronics boxes for the science data and control of the focal plane moving mechanisms.

   (ii) A digital electronics box for instrument control and telemetry interface to the spacecraft.

   (iii) A box containing the electronics required for the task of data compression. (ii) and (iii) could be contained inside one physical box.

4. Interconnecting harnesses, connecting the so-called "warm" boxes.

4.5 SOFTWARE DESCRIPTION

TBD

4.6 OPERATING MODES

4.6.1 Primary operating modes

PHOC will have two primary operating modes, 2-band photometry and line spectroscopy. From the variety of observations foreseen, it is expected that both modes will make use of all pointing modes supported by the satellite. Due to the much higher bandwidth in photometry mode, the instrument-internal data rate will also be higher in this mode; however, data compression/reduction in a dedicated electronics unit (PHO4b) will ensure that the data rate to the satellite will not exceed the allowed maximum rate in either operating mode.
The power dissipation into the 4 K level will be different for the two modes; 6 mW (averaged) from the grating drive and readout will occur in spectroscopy mode but not in photometry mode.

4.6.2 Parallel / Serendipitous mode

TBD

4.6.3 Stand-by mode

TBD

4.6.4 Off mode

TBD

4.6.5 FPU operations at ambient temperature

At ambient temperature the detectors and, most probably, the CREs will not be operational. However, all mechanisms (flip mirror, filter exchanger, chopper, and grating drive) and their position sensors will be functional to allow tests; also, continuity test of the wiring to the detector unit will be possible.

4.7 INSTRUMENT SCIENTIFIC PERFORMANCE

This part is to be considered as containing information which needs to be verified by test, analysis or a combination of the two and shall serve the purpose of demonstrating that the instrument will operate as intended for the particular mission.
Para 9.5 "Scientific Performance Verification" of the IIDs provides more information

on this subject.

4.7.1 Optical parameters

TBD

4.7.2 Spectral resolution

TBD

4.7.3 Modes of operation

TBD

4.7.4 Sensitivity

TBD

5. INTERFACE WITH SATELLITE

5.1 IDENTIFICATION AND LABELLING

Each individual instrument unit is allocated two unique identification codes:

- a project code which is the normal reference used for routine identification in correspondence and technical descriptive material.

- a spacecraft code allocated by the spacecraft contractor in accordance with the computerised configuration control system to be implemented, and used in particular for connector and harness identification purposes. The project code is part of the spacecraft code.(See IID-A, chTBD)

The project codes allocated to this instrument are:

Project code	Instrument unit
PHC1	Cold Focal Plane Unit
PHC2	Detector Control
PHC3	Mechanism Control
PHC4A, B	Digital Electronics, Data Compression Unit
PHC5	"Warm"Interconnect Harness

5.2 COORDINATE SYSTEM

Compliant with requirements in IID-A. Unit specific definition shown in the External Configuration Drawings.

5.3 LOCATION AND ALIGNMENT

Figures 1 and 2 show the location of the PHC Focal Plane Unit (FPU) on the Optical Bench (OB)

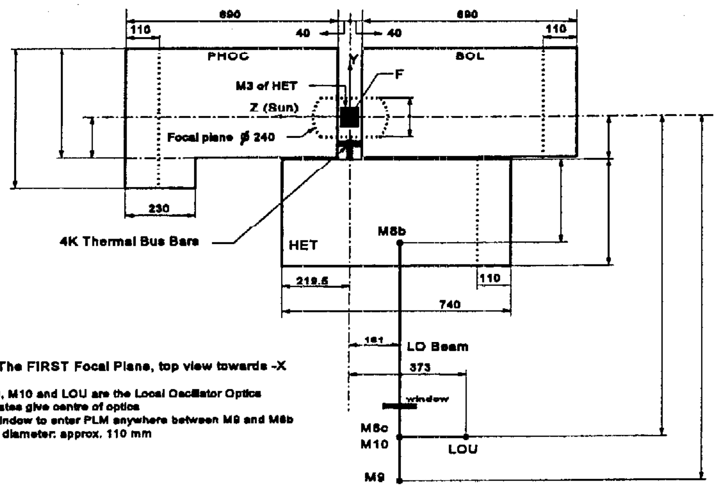


Fig. 1: The FIRST Focal Plane, top view towards -X

M8c, M9, M10 and LOU are the Local Oscillator Optics
Coordinates give centre of optics
Beam window to enter PLM anywhere between M9 and M8b
Window diameter: approx. 110 mm

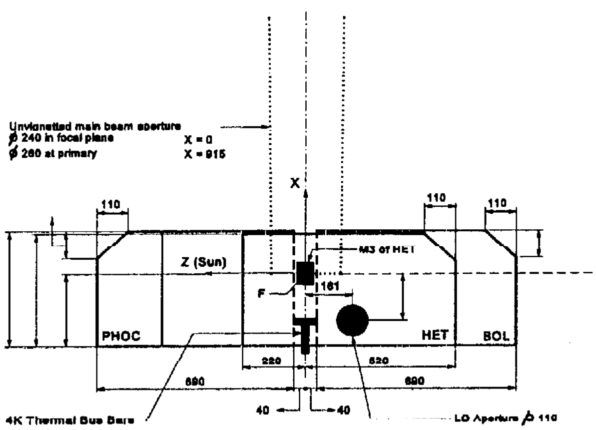


Fig. 2: The FIRST Focal Plane, side view towards +Y

5.3.1 Instrument Location

5.3.1.1 Inside cryostat

TBD

5.3.1.2 Outside cryostat

NA

5.3.1.3 On SVM

There are no location requirements for units on the SVM

5.3.1.4 On PLANCK module

NA

5.3.2 Instrument Alignment

There are no alignment and/or alignment stability requirements except for the focal plane unit PHC1.

5.3.2.1 Absolute Requirements

The absolute alignment requirements to the Optical Bench at operating conditions are as follows:

Unit	Δx	Δy	Δz	θx	θyz (combined)
PHC1	±1 mm	±1 mm	±1 mm	±5′	±3′

5.3.2.2 Stability Requirements

The stability requirements at operating conditions are as follows:

Unit	Δx	Δy	Δz	θx	θyz (combined)
PHC1	±0.1 mm/hr	±0.1 mm/hr	±0.1 mm/hr	±3 ′/hr	±1 ′/hr

5.4 EXTERNAL CONFIGURATION DRAWINGS

TBD

5.5 SIZES AND MASS PROPERTIES

The table below shows for each unit its size, mass (one unit) and the number of units:

Project code	Instrument unit	# of	Dimensions (mm)	Mass (kg)
PHC1	Cold Focal Plane Unit	1	690 x530 x410 Irregular shape	3~~2~~2
PHC2	Detector Control	1	200 x200 x150	4
PHC3	Mechanism Control	1	200 x200 x150	4
PHC4A	Digital Electronics	1	200 x200 x200	6
PHC4B	Data Compression Unit	1	200 x200 x150	3
PHC5	"Warm"Interconnect Harness	1		1
TOTAL				5~~4~~0

Note that dimensions and mass do/do not include margins. The S/C shall apply a margin of TBD %.

5.6 MECHANICAL INTERFACES

5.6.1 Inside cryostat

The Focal Plane Unit will have ~~4~~ 3 (TBC) holes for fixation by bolts to the Optical Bench. One of these holes is the reference hole, as marked in the External Configuration Drawing. The interface is such as to allow unit alignment and alignment-stability requirements to be fullfilled.

5.6.2 Outside cryostat

NA

5.6.3 On SVM

Units mounted on the SVM will have attachment points for fixation to the equipment platform. Units with a mass <1.5 Kg will not have more than 4 of these points. For units with a mass >1.5 Kg and units with a specific structural, dynamic or thermal requirement for more than 4 attachment points, the number will have to be approved by the Project.

5.6.4 On PLANCK module

NA

5.6.5 Cooler valves and piping

~~TBD~~ NA

5.7 THERMAL INTERFACES

5.7.1 Inside cryostat

The various instrument stages require 3 different temperatures. This will be achieved by strapping the stages to various "cold" parts of the cryostat.
These cryostat parts are:

- The He II tank for temperatures at the 2K level
- A wheel-shaped heat-exchanger cooled by the He-flow from the tank for the 4K level
- A connection to the He-ventline for the 15K level

The table below shows the required temperatures at the interface of the instrument unit with the cryostat or parts thereof:

Project code	Operating		Start-up	Switch-off	Non-operating	
	Min. K	Max. K	°C	°C	Min. °C	Max. °C
PHC1					Above dew point	+ 60 * + xx **

* Continuous temperature limit.
** Short-duration (bake-out yy hrs) temperature limit.

5.7.2 Outside cryostat

NA

5.7.3 On SVM

The table below shows the required temperatures at the interface of the instrument unit with the mounting platform or parts thereof:

Project code	Operating		Start-up	Switch-off	Non-operating	
	Min. °C	Max. °C	°C	°C	Min. °C	Max. °C
PHC2	- 15	+ 45	- 30	+ 50	- 30	+ 60
PHC3	- 15	+ 45	- 30	+ 50	- 30	+ 60
PHC4A	- 15	+ 45	- 30	+ 50	- 30	+ 60
PHC4B	- 15	+ 45	- 30	+ 50	- 30	+ 60
PHC5						

5.7.4 On PLANCK module

NA

5.8 OPTICAL INTERFACES

5.8.1 Focus location

TBD

5.8.2 Straylight

Instrument straylight model. TBD

5.9 POWER

5.9.1 Inside cryostat

The table below shows the heat dissipation of the units mounted inside the cryostat:

Project code	Instrument unit	Power Dissipation (W)
PHC1	Cold Focal Plane Unit	See:Thermal Table and Thermal Model

5.9.1.1 Thermal model PHC1

TBD

5.9.1.2 Thermal Table PHC1

Temp. level K	"15K" level K	Non-operating mW	Operating mW	Serendipity mW
2	_	0.08	0.23	0.23
4	12	_	9.9	_
4	14	_	10.0	_
4	16	_	10.3	_
4	18	_	10.5	_
4	20	_	10.6	_
4	22	_	10.9	_
4	23	_	11.0	_
4	24	_	11.4	_
4	26	_	11.6	_
23	_	0	43.0	_

Please note that 4K heatloads depend on "15K" level.

5.9.2 Outside cryostat

NA

5.9.3 On SVM

The table below shows the heat dissipation of the units mounted on the SVM:

Project code	Instrument unit	Power Dissipation (W)
PHC2	Detector Control	10
PHC3	Mechanism Control	10
PHC4A	Digital Electronics	10
PHC4B	Data Compression Unit	10
PHC5	"Warm"Interconnect Harness	

TOTAL		40

5.9.4 On PLANCK module

NA

5.9.5 Load on main-bus

The power load on the 28V. main-bus for this instrument is as follows:

Operating mode	Average BOL (W)	Average EOL (W)	Peak (W)
Primary mode	TBD	40	TBD
Parallel/Serendipity mode	TBD	TBD	NA
Stand-by mode	TBD	TBD	NA

5.9.6 Keep Alive Line (KAL)

TBD

5.9.7 Interface circuits

TBD

5.10 CONNECTOR, HARNESS, GROUNDING, BONDING

5.10.1 Connectors

TBD

5.10.2 Harness

5.10.2.1 S/C Harness

The S/C harness provides the interconnection between the instrument and two other subsystems i.e. the Power subsystem and the Datahandling subsystem.
The harness is supplied through the S/C Contractor.
On the instrument side, pin functions are specified in Annex A to this document.

5.10.2.2 Instrument Harness

The "warm" harness i.e the interconnect harness between the various "warm"

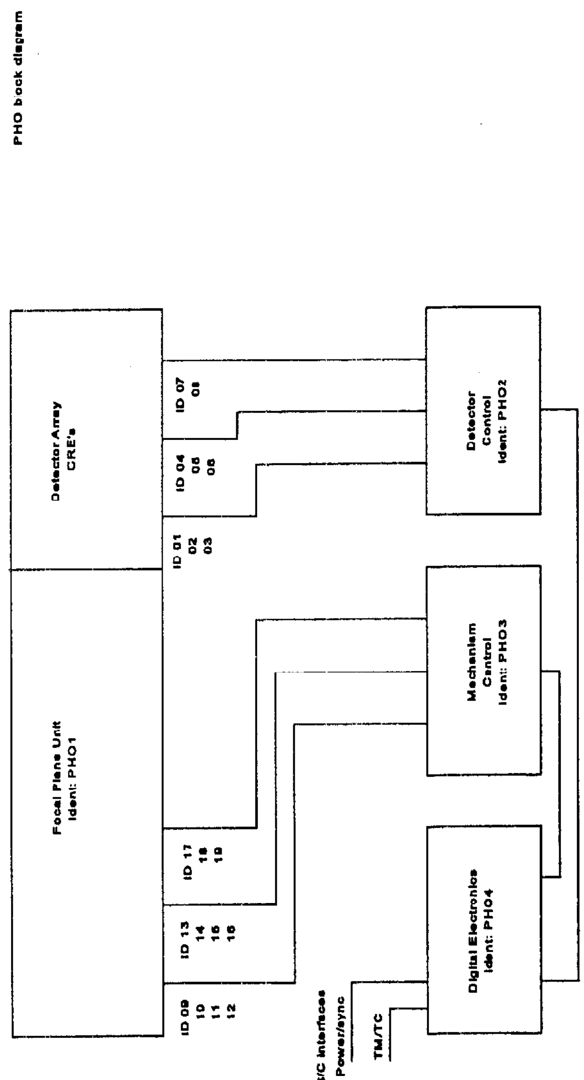
instrument units will be delivered by the instrument teams, manufactured to agreed requirements as specified in the IID-A under item 5.10.2.2.
Pin functions and wiring characteristics are specified in Annex A to this document. The Contractor will specify length and routing as soon as an SVM lay-out is available. A Configuration Drawing will be included under item 5.4

5.10.2.3 Cryo Harness

The cryo harness, interconnecting the 15 to 300 K instrument parts, will be delivered through the S/C Contractor, manufactured to agreed requirements.
The cryo harness interconnecting the 4 to 15 K instrument parts is considered part of the instrument and therefore to be manufactured by the instrument teams.
Pin functions are specified in Annex A to this document.

The blockdiagram and the tables below show the cryo harness composition both for the 4 to 15 K and the 15 to 300 K interfaces.

Figure 3: PHC block diagram



PHC cryo-harness list for 4 to 15 K interface level

	Instrument:PHC		Date	17/Jun/97				
	4 to 15 K interface	Type of cable		Allowed resist.	Current	Duty cycle	Max. line	Remarks
ID	Signal definition	# cond	# shields	(Ohm)	(mA)	(t * T)	volt. (V)	
1	Analog supplies	28	4	40	0.10	1	10.00	SST AWG38
2	Digital supplies & control	32	4	40	0.10	1	10.00	SST AWG38
3	Clock/sync/out	66	33	40	0.10	1	10.00	SST AWG38
4	Detector/Resistor bias-1	18	1	40	0.01	1	10.00	SST AWG38
5	Detector/Resistor bias-2	11	1	40	0.01	1	10.00	SST AWG38
6	Zero_Bias-1	16	1	40	0.01	1	10.00	SST AWG38
7	Zero_Bias-2	9	1	40	0.01	1	10.00	SST AWG38
8	Bias_Pres-1	16	1	40	0.01	1	10.00	SST AWG38
9	Bias_Pres-2	9	1	40	0.01	1	100.00	SST AWG38
10	Temp.sensors (1.7K/4.2K)	16	1	40	0.01	1	100.00	SST AWG38
11	Grating Position Sensor	6	3	20	5.00	0.40	100.00	Brass AWG38
12	Grating Drive Coils	8	1	20	20.00	0.40	100.00	Brass AWG38
13	Filter Flip Position Sensor	6	1	20	1.00	0.01	100.00	Brass AWG38
14	Filter Flip Drive Coils	8	1	15	20.00	0.01	100.00	Brass AWG38
15	Mirror Flip Drive Coils	8	1	15	20.00	0.01	100.00	Brass AWG38
16	Mirror Flip Position Sensors	6	3	20	5.00	0.01	100.00	Brass AWG38
17	Thermometers 4K	8	1	50	0.01	1	10.00	SST AWG38
	Total to instrument	271	59					

Notes: Allowed resistance values are at "operational temperatures"
In column Duty cycle t= part of T in which signal is active.

PHC cryo-harness list for 15 to 300 K interface level

	Instrument:PHC		Date	17/Jun/97				
	15 to 300 K interface	Type of cable		Allowed resist.	Current	Duty cycle	Max. line	Remarks
ID	Signal definition	# cond	# shields	(Ohm)	(mA)	(t * T)	volt. (V)	
1	Analog supplies	28	4	500	0.10	1	10.00	SST AWG38
2	Digital supplies & control	32	4	500	0.10	1	10.00	SST AWG38
3	Clock/sync/out	66	33	500	0.10	1	10.00	SST AWG38
4	Detector/Resistor bias-1	18	1	500	0.01	1	10.00	SST AWG38
5	Detector/Resistor bias-2	11	1	500	0.01	1	10.00	SST AWG38
6	Zero_Bias-1	16	1	500	0.01	1	10.00	SST AWG38
7	Zero_Bias-2	9	1	500	0.01	1	10.00	SST AWG38
8	Bias_Pres-1	16	1	500	0.01	1	10.00	SST AWG38
9	Bias_Pres-2	9	1	500	0.10	1	10.00	SST AWG38
10	Temp. sensors (1.7K/4.2K)	16	1	500	0.10	1	10.00	SST AWG38
11	Grating position sensor	6	3	250	5.00	0.40	100.00	Brass AWG38
12	Grating Drive Coils	8	1	250	20.00	0.40	100.00	Brass AWG38
13	Filter Flip Position Sensor	6	1	300	1.00	0.01	100.00	Brass AWG38
14	Filter Flip Drive Coils	8	1	250	20.00	0.01	100.00	Brass AWG38
15	Mirror Flip Drive Coils	8	1	250	20.00	0.01	100.00	Brass AWG38
16	Mirror Flip Position Sensors	6	3	300	5.00	0.01	100.00	Brass AWG38
17	Thermometers 4 K	8	1	500	0.01	1	10.00	SST AWG38
18	Calibration sources (2)	16	2	250	10.00	0.1	100.00	Brass AWG38
19	Cal.source temp. sensors	4	2	500	0.10	0.1	10.00	SST AWG38
20	Chopper drive	4	1	30	2.00	0.60	15.00	Brass AWG38 20 mA during transition
21	Chopper pos. sensors	6	1	45/22.5	1.00	1	10.00	Brass AWG38 22.5 Ohms for 2 wires
	Total to instrument	295	64					

Notes: Allowed resistance values are at "operational temperatures"
In column Duty cycle t = part of T in which signal is active.

5.10.3 Grounding

5.10.4 Bonding

5.11 DATA HANDLING

5.11.1 Telemetry

Housekeeping data rate	2 Kbps
Science data rate	40 Kbps

5.11.2 Timing and synchronisation signals

TBD

5.11.3 Telecommand

TBD

5.11.4 Interface circuits

TBD

5.12 ATTITUDE AND ORBIT CONTROL/POINTING, ON-TARGET-FLAG

5.12.1 Attitude and orbit control

At present no requirements other than those in the System Specification.

5.12.2 Pointing

TBD

5.12.3 On-target-flag (OTF)

TBD

5.13 ON-BOARD HARDWARE, SOFTWARE AND AUTONOMY FUNCTIONS

5.13.1 On-board hardware

TBD

5.13.2 On-board software

TBD

5.13.3 Autonomy functions

TBD

5.14 EMC

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TBD

5.14.2 Radiated Emission/Susceptibility

TBD

5.14.3 Frequency Plan

TBD

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5.15.3 Mechanical Ground Support Equipment (MGSE)

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5.15.8 Test Reference Data

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5.15.10 Technical Documentation

5.15.11 Transport and Handling Provisions

********The info below has to be merged in chapter 5.15.11************

5.15.1 Transport container

5.15.1.1 Focal Plane Unit

TBD

5.15.1.2 Electronic units and interconnecting harness

TBD

5.15.2 Cleanliness

5.15.2.1 Focal Plane Unit

The Focal Plane Unit/~~JFET Module~~ container must only be opened in a cleanroom environment of class 100 with a relative humidity of 50 %.

5.15.2.2 Electronic units and interconnecting harness

The Warm Electronics container must only be opened in a cleanroom environment of class 100 000 with a relative humidity of 50 %.

5.15.3 Physical handling

5.15.3.1 Focal Plane Unit

Condensation shall be avoided at all times.

Connection and disconnection of the instrument units during integration will be allowed under the following conditions:

- Take usual precautions against electrostatic discharge by grounding the operator.
- Before connecting, eliminate the electrostatic charges by a short-circuit device, to be provided with the instrument.
- Before connection or disconnection, be sure of the continuity between electrical and mechanical grounds.

Maximum rates of FPU warm-up and cool-down shall not exceed those specified in TBD.

5.15.3.2 Electronic units and interconnecting harness

Standard handling precautions shall be observed.

5.15.4 Purging

TBD

5.15.5 Mechanism positions

For reasons of possible damage caused by vibration during transport, environmental testing and launch mechanisms shall be placed in the TBD position. This position is shown in table TBD.

6. GROUND SUPPORT EQUIPMENT

7. INTEGRATION, TESTING AND OPERATIONS

7.1 Integration

7.1.1 FPU integration

TBD

7.1.2 "Warm-box" integration

TBD

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TBD

7.3 Operations

TBD

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