X-RAY MULTI-MIRROR MISSION

Optical Monitor
Experiment Interface Document

Part B

RS-PX-0018
Issue 5, Rev.-, dated 22 March 1996

Approved by: _____
K. van Katwijk (PX)

Approved by: _____
K.O. Mason (OM)

DISTRIBUTION LIST

ESTEC	**COPY**
Project	
R. Lainé (PX)	X
K. van Katwijk (PXP)	X
B. Jackson (PXS)	X
T. van der Laan (PXS)	X
G. Bagnasco (PXP)	X
M. Ditter (PXC)	X
O. Meert (PXC)	X
P. Glaude (PXQ)	X
H. Barre' (PXS)	X
H. Eggel (PXP)	X
J. van Casteren (PXS)	X
J. van Dooren (PXQ)	X
D. Green (PXC)	X
D. de Chambure (PXP)	X
F. Giannini (PXP)	X
P. Kletzkine (PXI)	X
S. Thürey (PXP)	X
A. Elfving (PXS)	X
A. Karlsson (PXS)	X
D. Stramaccioni (PXS)	X
F. Wechsler (PXI)	X
Science Department	
A. Peacock (SA)	X
C. Erd (SA)	X
K. Galloway (SA)	X
D. Lumb (SA)	X
R. Much (SA)	X
F. Jansen (SA)	X
P. Gondoin (SA)	X
K. Galloway (SA)	X
J. Riedinger (SA)	X
Informatics Department	
L. Jalota (WMA)	X
ESOC	
H. Nye (MOD)	X
J. Wardill (ECNOD)	X
N. Peccia (FCSD)	X

	COPY
OM	
R. Hunt (MSSL)	10 X
EPIC	
G. Villa (CNR)	5 X
RGS	
H. Aarts (ROU)	5 X
DORNIER	
W. Rühe	10 X

DOCUMENTATION CHANGE RECORD		
DATE	**ISS/REV**	**PAGES AFFECTED**
26-02-93	1/-	First formal issue. All pages at Issue 1
18-02-94	2/-	i-xiv, 1-33, 35-39, 41-64, 66-70
30-09-94	3/-	i, ii, 6, 9, 11, 12, 14, 17, 20-23, 25, 26, 28-32, 38, 39, 41, 43, 48, 57, 60, 68, 70
31-08-95	4/-	i-iii, vii-xiii, 3-5, 7-15, 17-20, 23-28, 32-33, 35-37, 39-44, 47-52, 56-61. The changes are marked in the right margin of each page.
22-03-96	5/-	i-iii, 9, 14-21, 25-26, 31-32, 34, 38, 40, 42-43, 47-49, 51-57, 59-60, 67-68 The changes are marked in the right margin of each page.

TABLE OF CONTENTS

1. INTRODUCTION 1
1.1 Structure and Content of the Document 1
1.2 Objective of the Document 2

2. INSTRUMENT DESCRIPTION 3
2.1 Hardware 3
2.1.1 Telescope Unit 3
2.1.2 Digital Electronics Unit 7
2.2 Mechanical Design 8
2.2.1 Telescope Unit 8
2.2.2 Digital Electronics Units 8
2.3 Mechanisms 10
2.4 Thermal Design 13
2.5 Electrical Design 14
2.6 Redundancy Concept 19
2.7 On-Board Software 19
2.8 Ground Support Equipment 21
2.8.1 Electrical Ground Support Equipment 21
2.8.1.1 Instrument Checkout 21
2.8.1.2 Interface Simulator 22
2.8.1.3 Science Data Terminal 22
2.8.2 Mechanical and Optical Ground Support Equipment 22
2.9 Instrument Modes Description 23
2.9.1 Operating Modes 23
2.9.1.1 Science Modes 23
2.9.1.2 Engineering Modes 24
2.9.1.3 Stand-by Modes 24
2.9.3 Non-operating Mode 24

3. MECHANICAL INTERFACES AND REQUIREMENTS 27
3.1 Identification Code 27
3.2 Location Requirements 27
3.3 Alignment Requirements 27
3.3.1 Telescope Unit 27
3.3.2 Digital Electronics Units and Interconnecting Harness Unit 27
3.4 Pointing Performance Goals 28
3.5 Interface Control Drawings 31
3.6 Instrument Allocated Mass 32
3.7 Instrument Estimated Mass 32
3.8 OM 1 Telescope Unit Stiffness Characteristics 32
3.9 OM 1 Telescope Unit Strenght Characteristics 32

4. THERMAL INTERFACES AND REQUIREMENTS 33
4.1 Temperature Limits in Space Environment 33
4.2 Temperature Limits in Laboratory Environment 33
4.3 Environment Requirements during Ground Storage and Transportation 34
4.4 Temperature Bake-Out Limits 34
4.5 Temperature Sensors 34

4.6 Heaters 34
4.7 Thermal Schematic 35
4.8 Thermal Control Requirements 37

5. ELECTRICAL INTERFACES AND REQUIREMENTS 38
5.1 Spacecraft Electrical Resources Requirements Summary 38
5.2 Instrument Power Distribution Block Diagram 39
5.3 Instrument Allocated Power 40
5.4 Power Budget at End of Life 40
5.5 Power Consumption Profiles 41
5.6 Telecommands 43
5.6.1 Telecommands Requirements 43
5.6.2 Telecommand Description 43
5.7 Telemetry 43
5.7.1 Telemetry Requirements 43
5.7.2 Telemetry Description 43
5.7.2.1 HK Telemetry 43
5.7.2.2 Science Telemetry 46
5.7.2.3 Engineering Telemetry 46
5.8 Electrical Interface Circuits 47
5.8.1 +28 V Power Interface 47
5.8.2 Keep Alive Power Interface 47
5.8.3 Converter Synchronisation Interface 48
5.8.4 Heater Power Interface 48
5.8.5 Digital Bus Interface 49
5.8.6 Analogue Data Channel Interface 49
5.8.7 Relay Status Monitor Interface 49
5.8.8 Telecommand (high level on/off) Interface 49
5.8.9 S/C Powered Temperature Sensors Interface 50
5.8.10 DBU Power Interface 50
5.8.11 Pyro Device Interface 50
5.9 Connectors and Harness Interfaces 51
5.9.1 OM 1 Connector List and Pin Function List 52
5.9.2 OM 2 Connector List and Pin Function List 55

6. EMC AND ESD INTERFACES AND REQUIREMENTS 58
6.1 Susceptibility Requirements 58
6.2 Frequency Plans for Units Emission 58

7. TRANSPORTATION, HANDLING, CLEANLINESS AND PURGING REQUIREMENTS 60
7.1 Transportation Requirements 60
7.1.1 Telescope Unit 60
7.1.2 Digital Electronics Units and Interconnecting Harness Unit 60
7.2 Handling Requirements 60
7.2.1 Telescope Unit 60
7.2.2 Digital Electronics Units and Interconnecting Harness Unit 60
7.3 Cleanliness Requirements 61
7.3.1 Telescope Unit 61
7.3.2 Digital Electronics Units and Interconnecting Harness Unit 61
7.4 Purging Requirements 63

7.4.1 Telescope Unit 63
7.4.2 Digital Electronics Units and Interconnecting Harness Unit 63

8. GROUND AND FLIGHT OPERATION REQUIREMENTS 64
8.1 Ground Operations 64
8.1.1 Assembly, Integration and Verification 64
8.2 Flight Operations 64
8.2.1 Avoidance Angles 65
8.2.2 Violation of the Sun Avoidance Angle Constraint 65
8.2.3 Calibration 65
8.2.7 Early Operations 66

9. DELIVERABLE MODELS AND GSE 67
9.1 Structural Thermal Model 67
9.1.1 Telescope Unit 67
9.1.2 Digital Electronics Units and Interconnecting Harness Units 67
9.1.3 Mechanical Ground Support Equipment 67
9.1.4 Electruical Ground Support Equipment 67
9.1.5 Optical Ground Support Equipment 67
9.2 Engineering Qualification Model 68
9.2.1 Telescope Unit 68
9.2.2 Digital Electronics Units and Interconnecting Harness Units 68
9.2.3 Mechanical Ground Support Equipment 68
9.2.4 Electrical Ground Support Equipment 68
9.2.5 Optical Ground Support Equipment 68
9.3 Flight Model 69
9.3.1 Mechanical Ground Support Equipment 69
9.3.2 Electrical Ground Support Equipment 69
9.3.3 Optical Ground Support Equipment 69
9.4 Flight Spare Model 69
9.4.1 Telescope Unit 69
9.4.2 Digital Electronics Units and Interconnecting Harness Units 69
9.4.3 Mechanical Ground Support Equipment 69
9.4.4 Electrical Ground Support Equipment 69
9.4.5 Optical Ground Support Equipment 69

LIST OF ABBREVIATIONS

AOCS	Attitude and Orbit Control System
BOL	Beginning of Life
CCD	Charged Coupled Device
CNR	Consiglio Nazionale delle Ricerche
CSL	Centre Spatial de Liege
DBI	Digital Bus Interface
DBU	Data Bus Unit
EGSE	Electrical Ground Support Equipment
EID	Experiment Interface Document
EMC	Electro Magnetic Compatibility
EOL	End of Life
EQM	Engineering Qualification Model
EPIC	European Photon Imaging Camera
ESA	European Space Agency
ESD	Electrostatic Discharge
ESOC	European Space Operation Centre
ESTEC	European Space Research and Technology Centre
FM	Flight Model
FS	Flight Spare Model
HK	Housekeeping
H/W	Hardware
ICB	Instrument Control Bus
IDL	Interactive Data Language
IR	Infra-red
LEX	Lexical Analizer
MGSE	Mechanical Ground Support Equipment
MLI	Multi-layers Insulation
MSSL	Mullard Space Science Laboratory
OBDH	On-Board Data Handling
OGSE	Optical Ground Support Equipment
OM	Optical Monitor
PI	Principal Investigator

RAM	Random Access Memory
RGS	Reflection Grating Spectrometer
ROM	Read Only Memory
ROU	Ruimte Onderzouk Utrecht
STM	Structural Thermal Model
S/W	Software
TBC	To be confirmed
TBD	To be determined
UV	Ultra Violet
XOMBI	XMM-OM Batch Interactive
XMM	X-Ray Multi-Mirror Mission
YACC	Yet Another Compiler Compiler

KEY PERSONNEL AND RESPONSIBILITIES

Mullard Space Science Laboratory
University College London
Holmbury St. Mary,Dorking
Surrey RH5 6NT
United Kingdom

Telefax : 44 1483 278312
Telephone : 44 1483 274111

Principal Investigator	:	Dr. K.O. Mason
Telephone (work)	:	44 1483 204157
Telephone (home	:	44 1483 267184
E-mail	:	kom@mssl.ucl.ac.uk
Instrument Manager	:	Dr. R. Hunt
Telephone (work)	:	44 1483 204170
Telephone (home)	:	44 1892870589
E-mail	:	rh@mssl.ucl.ac.uk
Product Assurance	:	Mr. A.P. Dibbens
Telephone (work)	:	44 1483 204194
Telephone (home)	:	44 1306 711127
E-mail	:	apd@mssl.ucl.ac.uk
Systems Electronics Engineer	:	Mr. N.R. Bray
Telephone (work)	:	44 1483 204194
Telephone (home)	:	44 1635 30134
E-mail	:	nrb@mssls7.mssl.ucl.ac.uk
Systems Mechanical Engineer	:	Ms. M.J. Carter
Telephone (work)	:	44 1483 204119
Telephone (home)	:	44 181 6435614
E-mail	:	mjc@mssl.ucl.ac.uk
Systems Software Engineer	:	Mr. H.E. Huckle
Telephone (work)	:	44 1483 204135
Telephone (home)	:	44 1403 733501
E-mail	:	heh@mssl.ucl.ac.uk
Detector Systems Engineer	:	Dr. H. Kawakami
Telephone (work)	:	44 1483 204197
Telephone (home)	:	TBD
E-mail	:	hk@mssl.ucl.ac.uk

Department of Astronomy
525 Davey Laboratory
Pennsylvania State University
University Park
PA 16802
U.S.A.

Telefax : 1 814 863 3399
Telephone : 1 814 865 0419

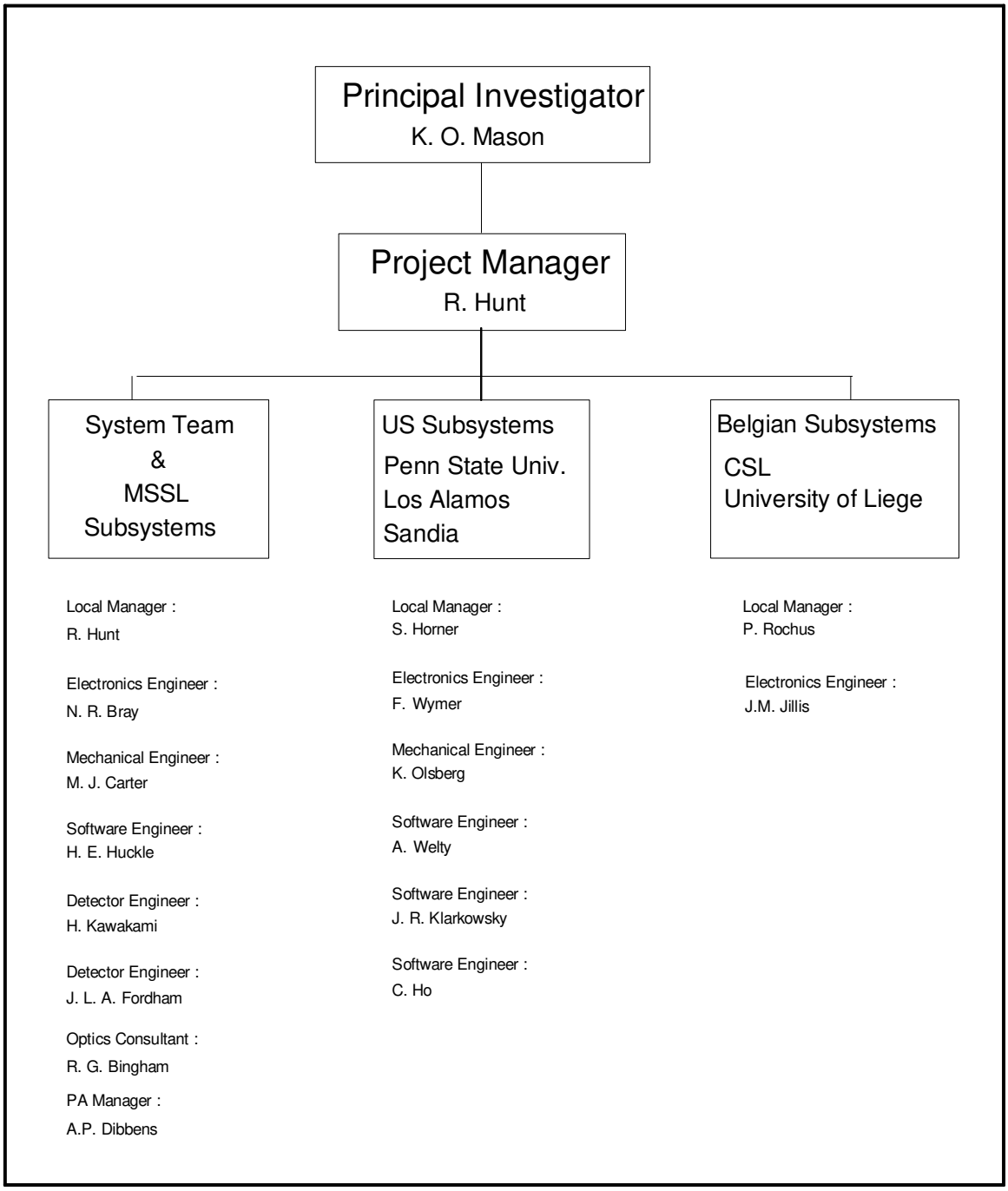
Local Manager, U.S.A. : Dr. S. Horner
Telephone (work) : 1 814 863 6041
Telephone (home) : TBD
E-mail : horner@astro.psu.edu

Centre Spatial de Liège
Avenue du Pre-Aily
B - 4031 Angleur-Liège
Belgium

Telex : 41320
Telefax : 32 4167 5613
Telephone : 32 4167 6668

Local Manager, Belgium : Mr P. Rochus
Telephone (work) : as above
Telephone (home) : not available
E-mail : cslulg@vm1.ulg.ac.be

OM Project Organigramme



INSTITUTES' RESPONSIBILITIES

The development responsibilities among the different institutes are as follows:

Institutes		**Responsibilities**
MSSL	-	Principal Investigator
	-	Project Manager
	-	Systems Engineering
	-	System-level Integration
	-	System-level Testing
	-	System EGSE
	-	Instrument Control Electronics
	-	Blue Detector
	-	Filter Wheel Mechanism
	-	Dichroic Mechanism
	-	Harness
	-	Telescope Structure
	-	Thermal Blankets
	-	System MGSE
Pennsylvania State University	-	Digital Electronics Unit Structure
	-	Data Processing Electronics
	-	Digital Electronics Power Supply
	-	EGSE Science Data Terminal
CSL	-	Telescope Module Power Supply
	-	System Level Test Facilities
	-	Optical Elements for the Filter Wheels and Telescope
	-	OGSE

1. INTRODUCTION

1.1 Structure and Content of the Document

The Experiment Interface Document (EID) forms the sole formal agreement on engineering, ground operations, flight operations, programmatics and management aspects for the XMM Project between ESA and each Principal Investigator (PI).

The document consists of five parts: one Part A, (document RS-PX-0016) common to the three instruments on board XMM (EPIC, OM, RGS), three Part Bs, one for each instrument, (document RS-PX-0018 for OM; document RS-PX-0019 for RGS; document RS-PX-0020 for EPIC) and one Part C (document RS-PX-0024), common to the three experiments.

Part A contains the ESA requirements of general nature to which each of the three instruments shall comply.

Each **Part B** contains both the PI's response to the requirements placed in Part A specifying, in detail, the Instrument's technical interfaces and the Instrument's requirements.

Chapter 2 of the present document is devoted to the general description of the Optical Monitor instrument.

As such, this chapter does not contain any requirement whatsoever and is therefore not applicable in any contractual sense.

Should there be any inconsistency between this chapter and the following chapters of this document, these following chapters will take precedence.

Part C contains the programmatic and management aspects governing the relations between ESA and the PI's.

Parts A, B and C of the EID will be put under formal configuration control by the ESA XMM Project Office and, as such, will be a binding agreement between ESA and the PI.

In cases of conflict between Part A and Part B of this document, the agreement or definition in Part B shall take precedence.

As a single point of control of the technical interfaces between ESA and the PI, the EID:

- Defines the resources allocated to the instruments
- Defines the system requirements
- Defines the interfaces between the instrument and the spacecraft
- Defines the design and construction requirements for the instruments
- Defines the verification programme which shall be implemented to demonstrate the instrument's compliance with the ESA requirements

- Defines the operational interface applicable during the ground phase of the mission, the post-launch support and the deliverable items.
- Defines the programmatic and management aspects

1.2 Objective of the Document

The EID helps to ensure that:

- The PIs design, build and verify their instruments within the constraints imposed by the payload, spacecraft and launch vehicle.
- The spacecraft Prime Contractor designs, builds and verifies the spacecraft in such a manner that the instruments can be successfully integrated into the system.
- The spacecraft system can be successfully launched and operated to achieve the scientific objectives of the XMM programme.

2. INSTRUMENT DESCRIPTION

2.1 Hardware

The Optical Monitor Instrument consists of 5 units :

1) One Telescope Unit (OM 1) containing :

   - the optical / UV telescope
   - the two redundant blue photon counting detectors, one prime and one cold redundant
   - the two filter wheel mechanisms
   - the dichroic mechanism
   - the power supplies & electronics

2) Two Digital Electronics Units (OM 2), one prime and one cold redundant; each one containing:

   - a data processing electronics
   - an instrument control electronics
   - a power supply electronics

3) Two Interconnecting Harness Unit (OM 3), one prime and one redundant, (between the Telescope Unit and the two Digital Electronics Units).

A schematic of the OM instrument is shown in figure 2.1a; the instrument hardware configuration is shown in figure 2.1b.

2.1.1 Telescope Unit

The optical train consists of a 300mm clear aperture Ritchey-Chretien telescope with a primary f/ratio of f/2.0 increasing to f/12.72 after the secondary.
The baffle system consists of an external baffle which extends beyond the secondary mirror, an internal baffle lining the telescope tube between primary and secondary mirror and primary/secondary baffles sorrounding the secondary mirror and the hole at the centre of the primary mirror. The two blue photon counting detectors are selected by the dichroic mechanism.

The blue beam is reflected by the dichroic through the filter wheel to the blue detector. In order to flatten the intrinsically curved focal plane the front surface of the detector window is concave (thinner at the centre), and the blue filters are weakly figured.

Two filter wheels, one for each blue detector, carries 7 filters, 2 grisms, a focal expander and a blocked position. The grisms offer limited spectral resolution (~1nm/pix). Two grisms are required to cover the full spectral range in the blue. The focal expander provides a 4x increase in image scale (to f/54 in the blue) to provide diffraction-limited images. This reduces confusion problems and permits the reaching of fainter limiting magnitudes at the centre of the field of view. The blue focal expander does not operate at UV wavelengths because of the limitation of transmission optics over a wide wavelength range. The gain in resolution from the magnifier will be realised only with a greater stability in the spacecraft pointing than currently specified. Simulations suggest that this will be possibly achieved; however the use of the magnifier is not to be regarded as a driver for the AOCS performances.

The two redundant detectors in the blue beam operate in a wavelength range between 170 and 600 nm. These are photon counting devices, based on a micro-channel plate intensifier. The photosensitive surface is an S20 photocathode with an active area 25 mm in diameter and a field of view of 23 arcmin on the diagonal. The detector format will be 2048 x 2048 pixels with each pixel ~9.6 µm square (the precise dimension depends on the curvature of the detector window and filter elements). There will be commandable stimulation of the detector for calibration purposes. In order to limit the processing and bandwidth requirements, the detector will allow 15 sub-areas of the active area to be defined by the user and will allow pixels to be binned 2 at a time.

Figure 2.1.a : Instrument Schematic

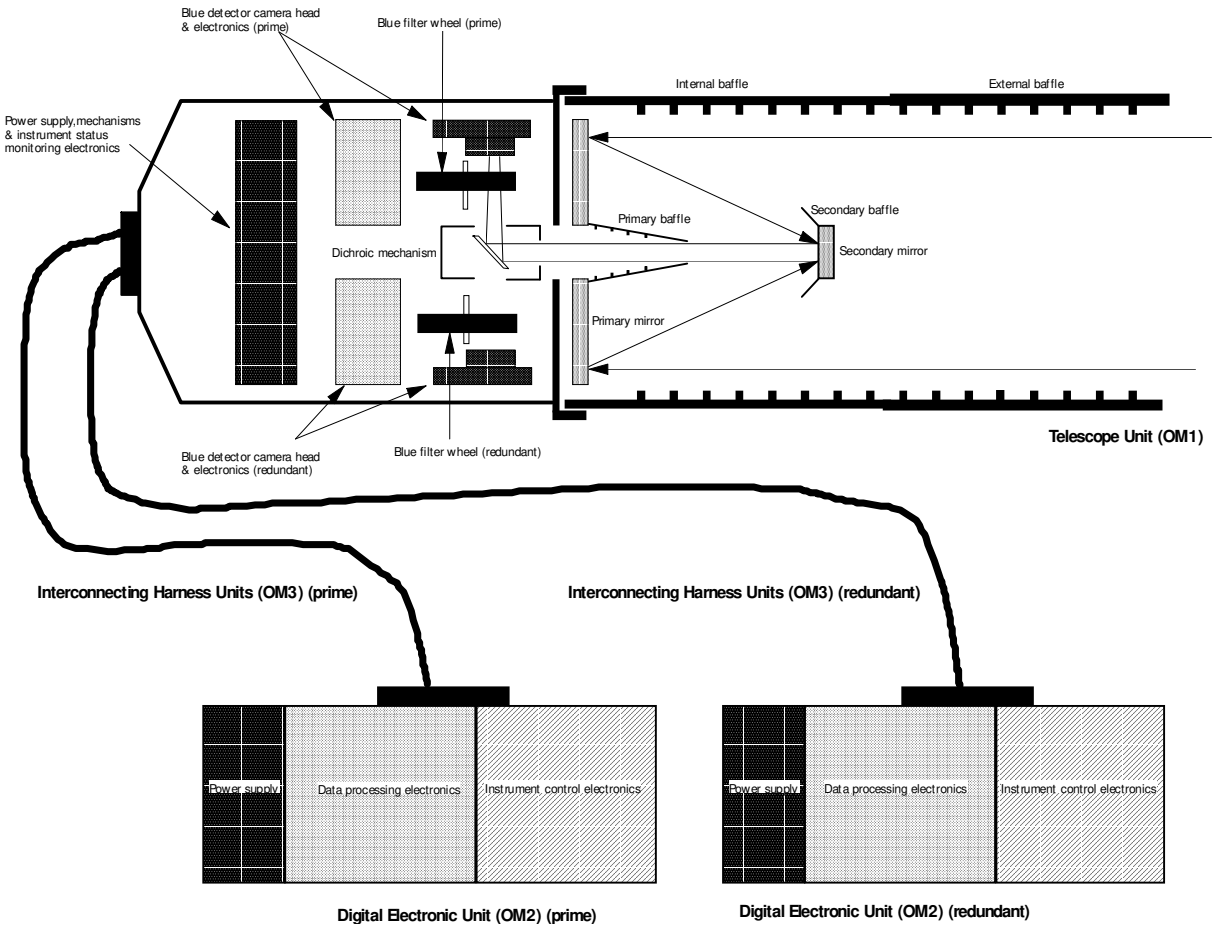
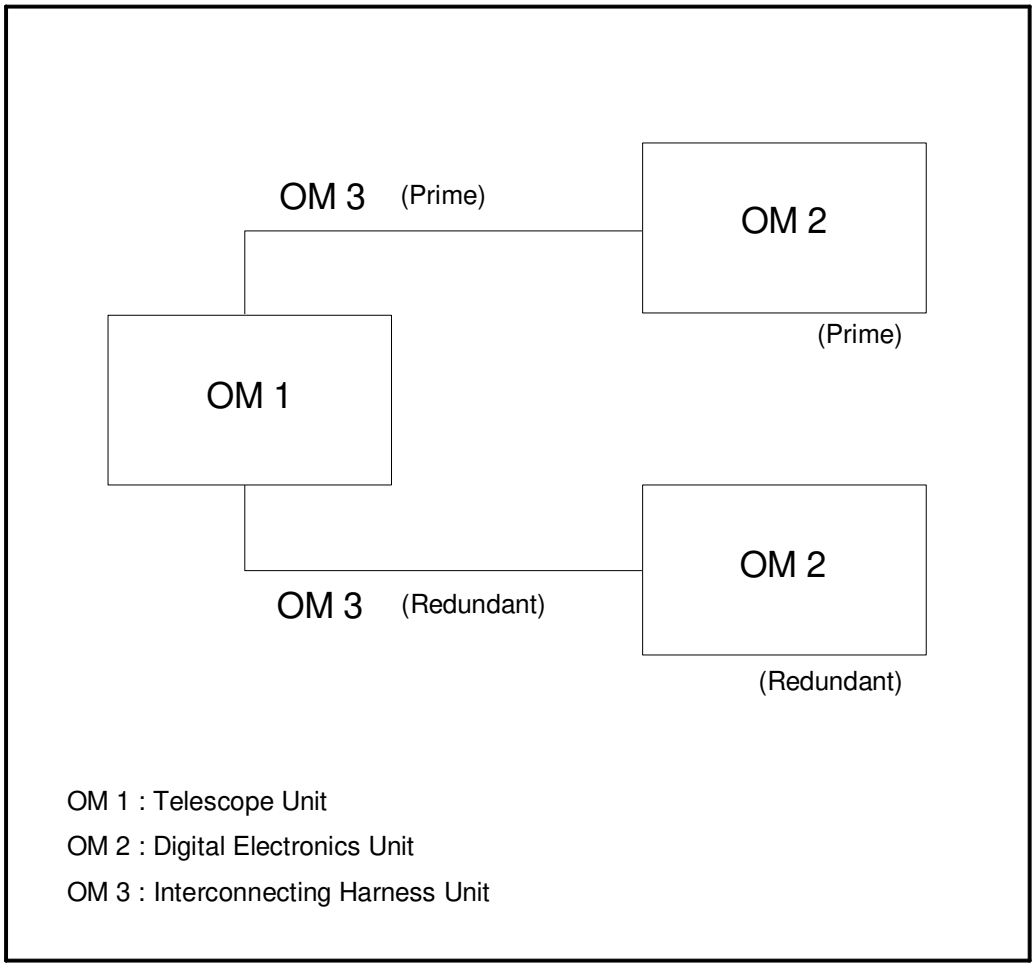


Figure 2.1.b : Instrument Configuration



2.1.2 Digital Electronics Unit

Each digital electronics unit consists of three modules : an instrument control electronics, a data processing electronics and a power supply electronics. Within each digital electronics unit, boards share a common backplane. The two harnesses (OM 3, prime and redundant) connect the two digital electronics units with the electronics in the telescope unit.

The instrument control electronics exercises overall control over the instrument and is responsible for interfacing to the spacecraft.

The data processing electronics is responsible for accepting the data from the detectors, compensating for spacecraft drift and accumulating and packaging the data before passing it on to the instrument control electronics for transmission.

The power supply electronics provides the power to the digital electronics units.

2.2 Mechanical Design

2.2.1 Telescope Unit

The overall telescope unit configuration is shown in figure 2.1.a.
The blue detectors are separated by 180 degrees about the optical axis.
This optimizes the use of the limited space behind the primary mirror. The power supply electronics contains the motor drive circuits for the 3 mechanisms.

The telescope unit can be divided into a number of modules. This type of concept enables considerable assembly, integration and test of the blue module and telescope to take place independently. It also means that interfaces are minimised and optical alignment eased. The tube of the telescope has a central girdle ring, which is provided with attachments for connection to the mirror support platform. The primary and secondary mirrors will be made from Zerodur. There is no focus mechanism. Focus is maintained by the intrinsically thermally stable invar structure between primary and secondary mirrors.

The structural tubes behind the primary mirror houses the detectors and mechanisms on two bulkheads (see figure 2.2). The first bulkhead serves as the optical bench for the blue module with detectors, filter wheels and dichroic mechanism on its forward face and electronics on its rear. The structural integrity of the blue detectors is aided by bracing them to a central square column carrying the dichroic mechanism. The second bulkhead carries the TMPSU and the external connector panel.

2.2.2 Digital Electronics Units

There are two identical digital electronics units, one being redundant to the other. These are mounted, separately from the telescope unit, on the mirror support platform. Both units are box structures machined from solid. Inside each unit there are a number of modules that mate with a motherboard. The modules consist of printed circuit cards held in frames. Due to the position of these units, additional shielding surrounds them on all the external faces except for the base.

Figure 2.2: Telescope Unit Modularity

2.3 Mechanisms

There are three mechanisms in the instrument.

The two blue filter wheel mechanisms are identical and fully redundant. Each one carries seven filters, one blocked position, two grisms and a focal expander. Each wheel rotates on a stub axle, which is in turn mounted on a baseplate. A ring gear, outside the filters, is driven by a stepper motor, also mounted on the baseplate. Both baseplates are firmly bolted to flat faces on the square central column surrounding the dichroic mechanism.
Figure 2.3.a shows the design of the filter wheels.

The dichroic mechanism, driven by a stepper motor, comprises a cylinder which can rotate around the axis of the incident beam. The dichroic itself is mounted on one end of the cylinder.
Figure 2.3.b shows the design of the dichroic mechanism.

Figure 2.3.a: Filter Wheels Mechanism

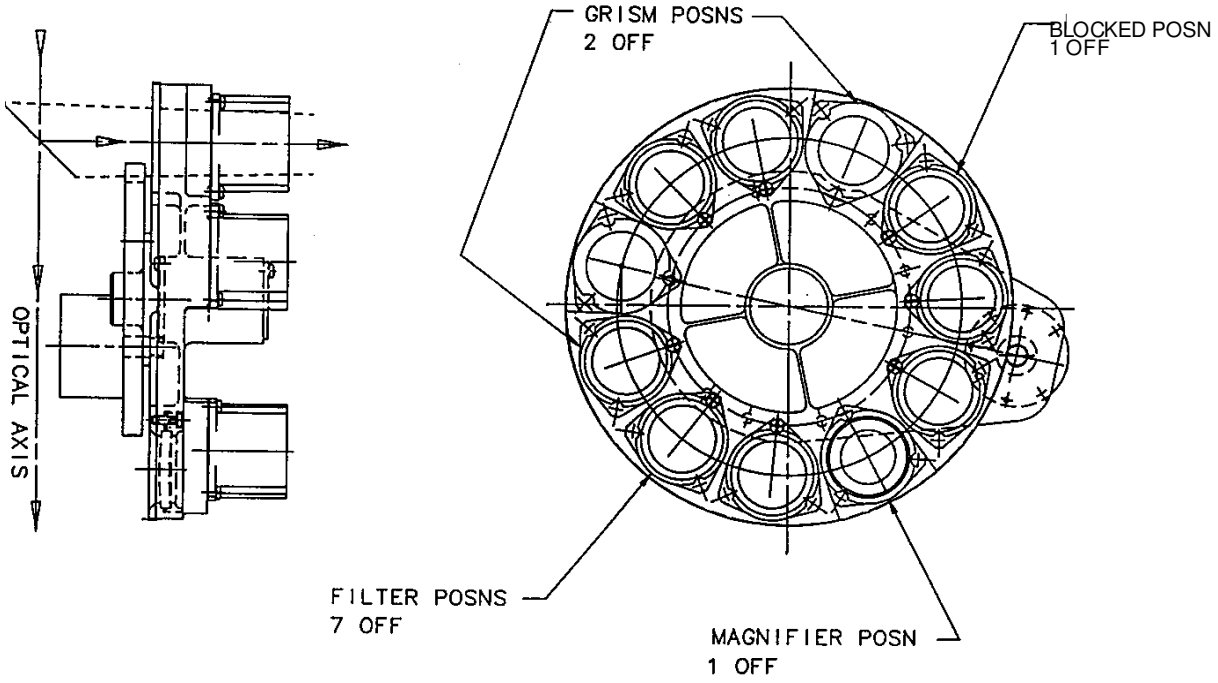
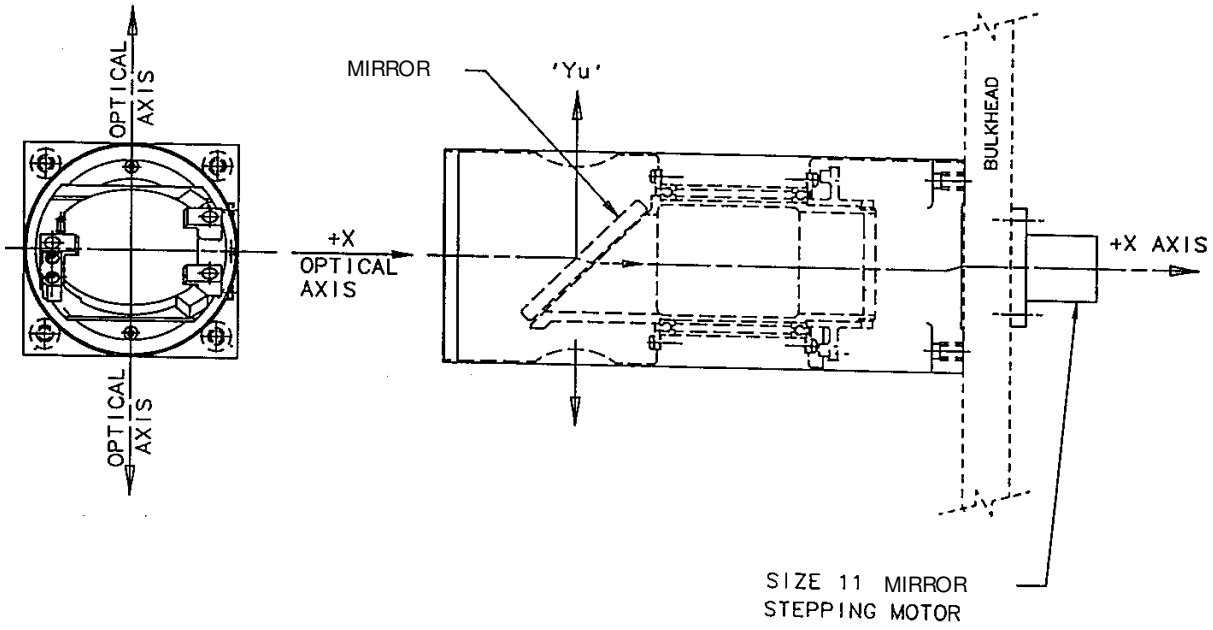


Figure 2.3.b: Dichroic Mechanism



2.4 Thermal Design

The thermal design of the telescope unit is constrained by the requirement that the telescope structure (internal to the telescope unit) must be maintained to within +/- 1.1þC of its design temperature (nominally 20þC) in order to maintain the separation between the primary and secondary mirrors;

In addition to this particular requirements there are standard requirements on the thermal design of the instrument in order to safeguard the operation of the electronics. This control will be active, swithched by relays, in the telescope unit and passive in the digital electronics units.

Heaters and thermal monitoring circuits will be used in the telescope unit in addition to thermal blankets on that part which protrudes from the front of the mirror support platform.

2.5 Electrical Design

The electronics is housed in the two digital electronics units (one prime and one cold redundant), and inside the telescope unit. At any time during instrument operation one of the two digital electronics units will be switched on and will perform digital data processing and telemetry formatting in addition to instrument supervisory control. The telescope unit contains all the instrumentation and pre-processing electronics together with local power supplies.

Figure 2.5.a illustrates the configuration of the major external interfaces for power, sync, data and control. Primary and redundant power are routed directly to the telescope unit. The 2 digital electronics units are powered separately, one from the primary and the other from the redundant supplies routed from the telescope. Uplink and downlink data from and to the instrument are carried by the digital bus interfaces with the digital electronics units. Between these two units and the telescope there are two types of digital links. The detector data interface carries detector data from the telescope to the active digital electronics unit where it is then processed for telemetry. Monitoring and control of the electronics inside the telescope are performed via the other link, the instrument control bus, which is redundant and under command of the active digital electronics unit.

The power supply electronics inside the telescope unit contains converters for routing conditioned power to its subsystems. In addition, it contains circuitry to drive the mechanisms and relays to route up to 10 W of raw power to the heaters.

There are two keep alive interfaces to the OM. They are routed through the telescope unit one to the prime digital electronics unit and the other to the redundant unit. Inside each digital electronics unit power supply the keep alive rail is converted to 3.2 V and used for maintaining the power to static RAMs when the main supply is off.
The electronics internal to the telescope unit (see figure 2.5.b) is divided into two chains, which drive the blue detectors and are redundant.

The blue detector processing electronics are physically combined with the electronics to receive thermistor and motor pick off signals. They share the same instrument control bus connections and are manufactured and tested as a single module.

The internal structure of each digital electronics unit is illustrated in figure 2.5.c.
It shows that there are three modules: the data processing electronics, the instrument control electronics and power supply electronics. The overall instrument function is controlled by the instrument control electronics, that drives the redundant instrument control bus. This is a serial command/data bus based on the MACS-bus and is used to carry set-up information to most modules in the telescope unit and status and housekeeping information back to the instrument control electronics. The MACS-bus has two lanes both of which go to each instrument control electronics. The science data is not carried on the instrument control bus, but on a separate interface from the detectors to the data processing electronics and another interface to the instrument control electronics. The detector data interface is a 3-wire link with clock, data and envelope signals, and is capable of high data rates. It is two-way in the case of the instrument control electronics to the data processing electronics link, so command and set-up information to the data processing electronics and status and housekeeping from the data processing electronics is carried on this link. There is therefore no connection of the data processing electronics to the instrument control bus.

The instrument has the capability to time-tag data to a resolution of 1/1024 sec. Using the clock and time signal provided by the spacecraft, the instrument control electronics and the data processing electronics will have internal clock registers and signals available to the required resolution, synchronised with the spacecraft time clock.

A small amount of ROM is used on-board. The code is copied into RAM and the ROM is switched off.
The flight software will always be held in RAM made non-volatile by a keep-alive-line with hardware write protection. The consequence of such a scheme is that it will require the spacecraft to upload the flight software after initial switch on.

The data processing electronics is responsible for accepting the data from the detectors and removing the effects of spacecraft pointing drift before accumulating the data. Each data processing electronics is based on 4 digital signal processors (Motorola DSP56001) sharing approximately 11 Mbyte of data memory in addition to local and programme memory. This large memory array is necessary to handle the large format detectors.

Each detector will carry a low-intensity flood illumination source. This can be activated by s/w control and has been incorporated in order to provide for flat field calibration of detectors. This corrects for the detector response on small scale. The sources will not be uniformly bright on large scale and their stability is not guaranteed: therefore they will not be useful for absolute flux calibration of the detectors. However, they will be useful in providing an indication of the operational status of the detector.
The source will be located on the detector camera head in such a way that the light can be reflected off the rear of the blocked filter when it is selected. This surface will be treated to provide the appropriate non-specular reflective characteristics. The source will be activated by command to the respective detector via the ICB.

Figure 2.5.a: Configuration of Major Electrical Interfaces

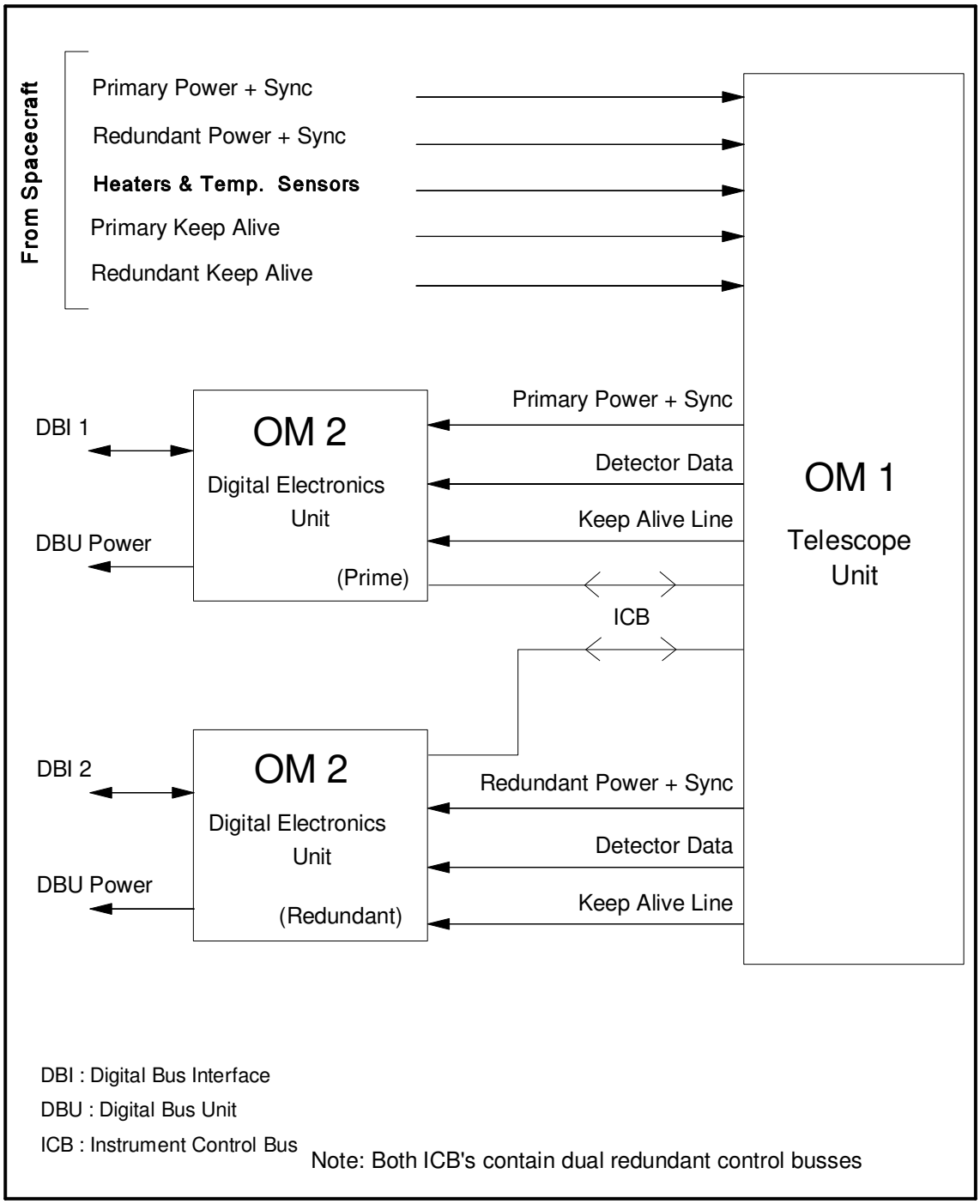
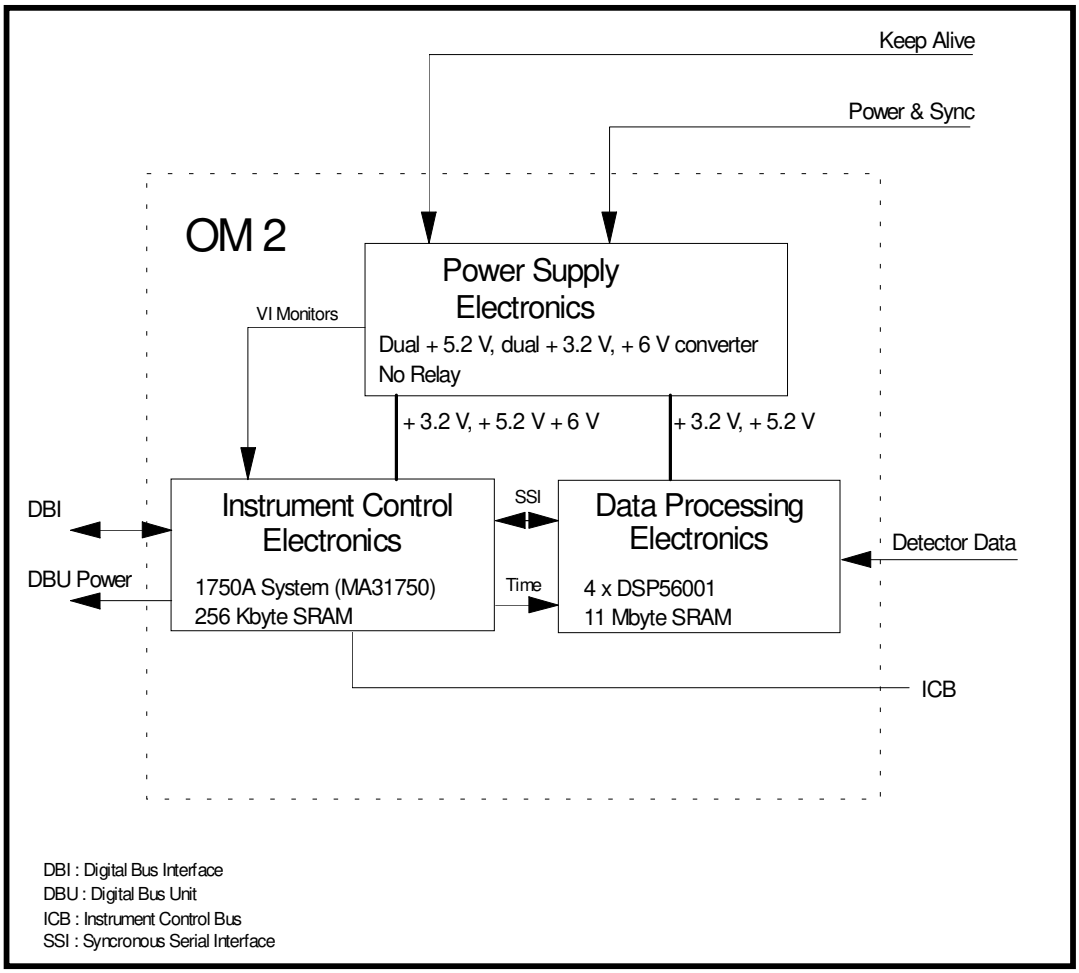


Figure 2.5.b: Electrical Interfaces at Module Level inside the Telescope Unit

Figure 2.5.c: Electrical I/Fs at Module Level inside the Digital Electronics Unit



2.6 Redundancy Concept

The instrument is redundant with respect to its blue detector module.

Power for the digital electronics unit and the detectors electronics are separate. Main and redundant power are used separately to supply the two digital electronics units without switching. Primary power is routed to drive the prime converter inside the telescope unit; redundant power is routed to the redundant converter. The outputs of the converters are independently switched and go to the blue electronics (including high voltage units).

Control interfaces are bi-directional. There is one control bus for each detector chain. The power supply is controlled as two separate modules: each blue detector is a separate module. Any module that is powered will receive commands and send responses via its control bus.

2.7 On-Board Software

The overall instrument function is controlled by the instrument controller electronics. Its code will be written in the ADA language. The software functions are as follows:

1) schedule and monitor an observing sequence;

2) configure the instrument by switching parts of the instrument on or off;

3) monitor and make the instrument safe in breakdown/failure conditions;

4) control and interpret the returned status from the detectors, the telescope power supply and the data processing electronics;

5) interpret and execute telecommands;

6) incorporate uplinked new or modified code modules for itself or for the Data Processing Electronics.

7) collect and prepare instrument housekeeping and engineering packets in preparation for telemetering;

8) accept science data from the active data processing electronics into packets, and accept and prepare tracking information packets, in preparation for telemetering;

9) interface with the OBDH for data and commands;

10) distribute drift information derived from the active data processing electronics to the detector modules via the instrument control bus;

11) monitor and maintain thermal control of the OM telescope unit.

The data processing electronics is responsible for processing the data from the active detector module~~s~~. The tracking information so obtained will be used in two ways:

1) data taken within each tracking frame are shifted with respect to an initial master frame and summed to form the final image 24 bit deep;

2) the tracking information is forwarded to the instrument control electronics which in turn uses the information to update window boundaries on the detector

By using the two science modes available the data processing electronics will be able to compress the intrinsic high count rate of the photon counting detectors into the allocated telemetry bandwidth and to determine the absolute pointing of the instrument.
Of the 4 data signal processors in the data processing electronics, two signal processors have been allocated to the blue detectors. The master, or 'white' data signal processor, has been allocated image recognition and data compression tasks, while the 4th signal processor performs image shifting tasks.

The bootstrap and part of the operational software is the only flight code stored in ROM.

The bootstrap routine is executed on the instrument control electronics, initially appearing in the processors memory map, following power-on or reset. Its function is to ensure that the instrument control electronics instruction space contains an executable image in RAM. On completion of its tasks it starts execution at the entry point and is paged out such that the processor only sees RAM in its address space. The only issues to be tackled by the bootstrap are to select and then to source the code to generate the executable image including some verification.
It can load code from one of four sources, namely:
1) the spacecraft interface
2) the existing image;
3) internal storage;
4) the EGSE.

On startup, the bootstrap shall wait for a spacecraft command to select one of the first 3 sources. If no command is forthcoming during a default period, the existing image will be selected if it is valid. Otherwise code will be loaded from the EGSE, if its presence is detected, or from internal storage (into which code would have been uplinked earlier).

2.8 Ground Support Equipment

2.8.1 Electrical Ground Support Equipment

The EGSE will be based around three parts, the interface simulator, the instrument checkout computer and the science data analysis terminal.

The interface simulator will be based around a VME crate running the VxWorks realtime operating system.
The science data analysis terminal will be used to verify the scientific performance of the instrument.

The instrument check-out computer and the science data analysis terminal will be based on Sun work stations with an X-based graphical user interface. They will be running a Unix-based operating system. They will be connected to an ethernet and communicate via a standard Ethernet protocol (initially TCP/IP).
The instrument check-out computer will provide the commanding (manual and automated), real-time display and archiving functionality.

All units will have internal power supplies that can be operated from 220/240 volt 50 Hertz supply. The EGSE will require only one mains power point and will distribute its own power including two spare points for the connection of diagnostic equipment.

The telescope unit will provide stimulation to the detector modules internally for testing and verification.

2.8.1.1 Instrument Checkout

The instrument check-out software will be coded in C.

The control files for the unit level EGSE will be written in a language specified by the consortium. It is not planned to use ETOL. A language designed specifically for OM will be used instead. It will be syntactically similar to the VxWorks language.

For system level tests the central check out system will need to process the control files developed during unit level testing, in order to avoid substantial recoding.

The instrument check-out computer code will make substantial use of X-window `widgets' - buttons, sliders, menus etc - to facilitate ease of input and display of output. It will be possible to take hardcopies of all screen displays. Hardcopy files will be in Postscript. On-line help will be provided.

2.8.1.2 Interface Simulator

The interface simulator will be a VME rack containing interface cards and a controlling 68030-based CPU card running VxWorks. VxWorks is a real-time multi-tasking operating system with task synchronisation and resource exclusion facilities which provides:

i) a text based command interface with a Unix "flavour" and script facilities
ii) close coupling with the file system of the host check-out computer for easy data storage and recovery
iii) TCP/IP ethernet based communication with the host (with "logon" support).

2.8.1.3 Science Data Terminal

The science data analysis terminal software will be based on the Interactive Data Language analysis package.

For the purpose of the science data analysis terminal, data can be classified as image, time series or spectral (from grims). For each type, the science data analysis terminal will read or write the data from disk or magnetic tape, display on the workstation screen and produce hard copies of images and graphics output. For all types, it will be possible to manipulate, model and analyse the data.

Each of the above will be performed in a user friendly manner by using the interactive data language widgets. Buttons and sliders will be provided to give the user control of the data representation (e.g. colour tables, contrast, axis ranges and labels etc). Archived files will be able to be selected from a list.

A log will be maintained automatically for each session specifying the major operations performed, the data on which they were performed, and the values of important parameters. On-line help will be provided.

Data files will be written in FITS format. Hardcopy files will be in Postscript.

2.8.2 Mechanical and Optical Ground Support Equipment

The telescope unit will be delivered fully aligned internally.
External alignment to the S/C reference axes will be carried out via reference cubes on the telescope unit structure. No specific OGSE will be provided for the telescope unit to support this alignment.

No reference cubes or OGSE are needed for the digital electronics units.

MGSE will be supplied to aid handling, mounting and alignment of the telescope unit and two digital electronics units. In addition, the MGSE will provide the environment required to meet the cleanliness specification during transportation and before, during and after integration into the spacecraft.

2.9 Instrument Modes Description

2.9.1 Operating Modes

2.9.1.1 Science Modes

Two science modes are available in addition to the engineering modes which are used to check the performance of the instrument.

In IMAGE MODE, data is integrated for a time period known as the tracking frame time (<= 20 secs) into a tracking frame image. These tracking frame images are then shifted to compensate for spacecraft pointing drift (but not roll) and summed into an accumulating image to produce a single integrated image covering the entire exposure. The exposure time must therefore be a multiple of the frame time. The shift is derived from positions of the brightest stars in the image. Were the shifting not carried out, the image blurring caused by spacecraft drift would be unacceptable over typical exposure times. The maximum exposure time is set by the blurring at the edge of the field of view as a result of the spacecraft roll, which cannot be corrected.

In FAST MODE, the successive time slices of the image are not accumulated but stacked. The drift compensation is not carried out, although it is calculated and telemetered with the data. The minimum integration time per time slice is 1 msec.

It is not possible either to process, store or telemeter the full active area of the blue detectors. This would amount to 12 Mbyte per image. Provision has been made, therefore, for parts of the detector active areas to be selected, or `windowed'. Up to 15 windows will be employed, from 6 to 10 of which will be used for tracking. The maximum amount of active area that can be used for an exposure is set by the memory size and the exposure times. In addition, provision has been made for pixels to be binned up by powers of 2 in order to store, process and telemeter the full detector area at a lower spatial resolution. Window borders are quantised on a factor of 8 for the fast mode and 16 for the image mode. Window borders will be updated, if necessary, in order to prevent images from crossing a window perimeter as a result of spacecraft drift. The size of the fast mode windows is limited by the telemetry bandwidth.
There will be two sets of fast mode windows, a set having all the same integration time. Within each set, the total number of pixels in windows will not exceed 512.

On the blue detector both image and fast mode can occur simultaneously. For example, there can be both image and fast mode windows open at the same time. These windows can be superimposed, but their perimeters may not intersect.

The decision on the window, binning and observing mode selection, the filters and exposure times on the setup is made by the observer beforehand.

The full images produced in both science modes will be compressed into the allocated telemetry bandwidth. The compression scheme to be adopted is not yet defined.

The N brightest stars from the initial reference frame will be selected. Data on these stars will be provided at frame time intervals. It will consist of centroid and peak coordinates, integrated and peak counts, parameters describing the window used to delineate the stellar image and moments. Alternatively, the N brightest stars from each frame are described instead. These

options are called 'Bright Star' and 'Threshold'.

2.9.1.2 Engineering Modes

In addition to the science modes discussed above there will be engineering modes for the blue detectors.

1) a full 2048 x 2048 unbinned frame without image registration in the digital processing electronics; this can be telemetered in full (16 bit deep) or simply stored for analysis;

2) storage of each raw event as photon event list;

3) intensifier characteristics data

4) centroid table data

2.9.1.3 Stand-by Modes

The are 3 stand-by modes.
The first is the SAFE MODE; in which the filter wheels are rotated to their blank position and the blue detector high voltages are off.
The second is the IDLE MODE in which full instrumental capability is available, except that no data are taken.
The third is the INITIAL STATUS MODE which defines the initial electrical status of the instrument after switch-on.

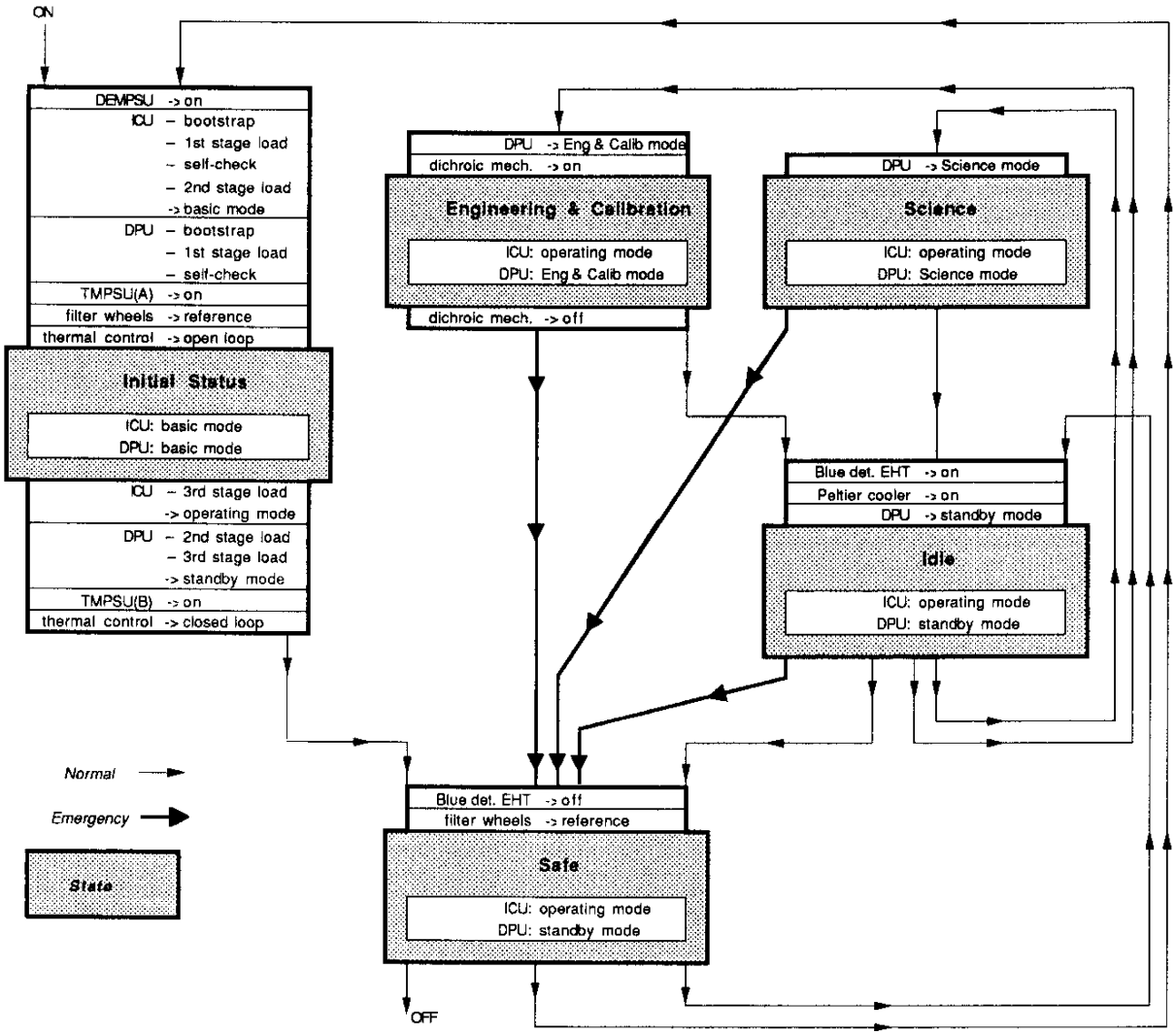
2.9.3 Non-operating Mode

There is only one non-operating mode: the OFF MODE in which the instrument is not powered.
The instrument can access the OFF MODE only from the SAFE MODE.

The characteristics of each mode are shown in table 2.10. The modes transition diagram is shown in figure 2.10.

Table 2.9.3: Modes Characteristics

Figure 2.9.3: Modes Transition Diagram



3. MECHANICAL INTERFACES AND REQUIREMENTS

3.1 Identification Code

The units shall be uniquely identified by the following project codes:

Project Code	Instrument Unit	Number of Units
OM 1	Telescope Unit	1
OM 2	Digital Electronics Unit	2
OM 3	Interconnecting Harness Unit (between OM 2 and OM 1)	2

The complete hardware configuration with the total number of units is shown in figure 2.1.b

3.2 Location Requirements

The location requirement for each unit and the maximum interconnecting harness length are specified below:

Unit	Location
OM 1	Mirror Support Platform
OM 2	Mirror Support Platform
OM 3 (prime)	Mirror Support Platform; their length shall be þ 3 m
OM 3 (redundant)	Mirror Support Platform; their length shall be þ 3 m

3.3 Alignment Requirements

3.3.1 Telescope Unit

In orbit, the angular deviation of each of the three EPIC bore sights (1) and the OM optical axis shall lie within a 1 arcmin radius circle.
(1) See EID-A para. 4.2.3.1

3.3.2 Digital Electronics Units and Interconnecting Harness Unit

No specific alignment requirements.

3.4 Pointing Performance Goals

In order for the drift compensation technique to operate successfully, the drift of the spacecraft should not exceed more than one blue detector pixel in an guiding frame time. The pixel size is 0.5 arc sec and nominally the guide frame period is 10 seconds. This gives rise to the requirement that the pitch and yaw of the spacecraft should be within 0.5 arc sec at timescales of 10 seconds and less, for 95% of the active observing time. For the purposes of this discussion, this has been translated to a 95% tolerance of ± 0.25 arc sec single axis. The stability is different for different timescales, and the above figure can be relaxed for longer timescales. At the 2 minute timescale, a ± 3 arc sec 95% tolerance is adequate. At longer timescales, this can be relaxed even further.

The drift performance goals are given in the table below and in figure 3.4.

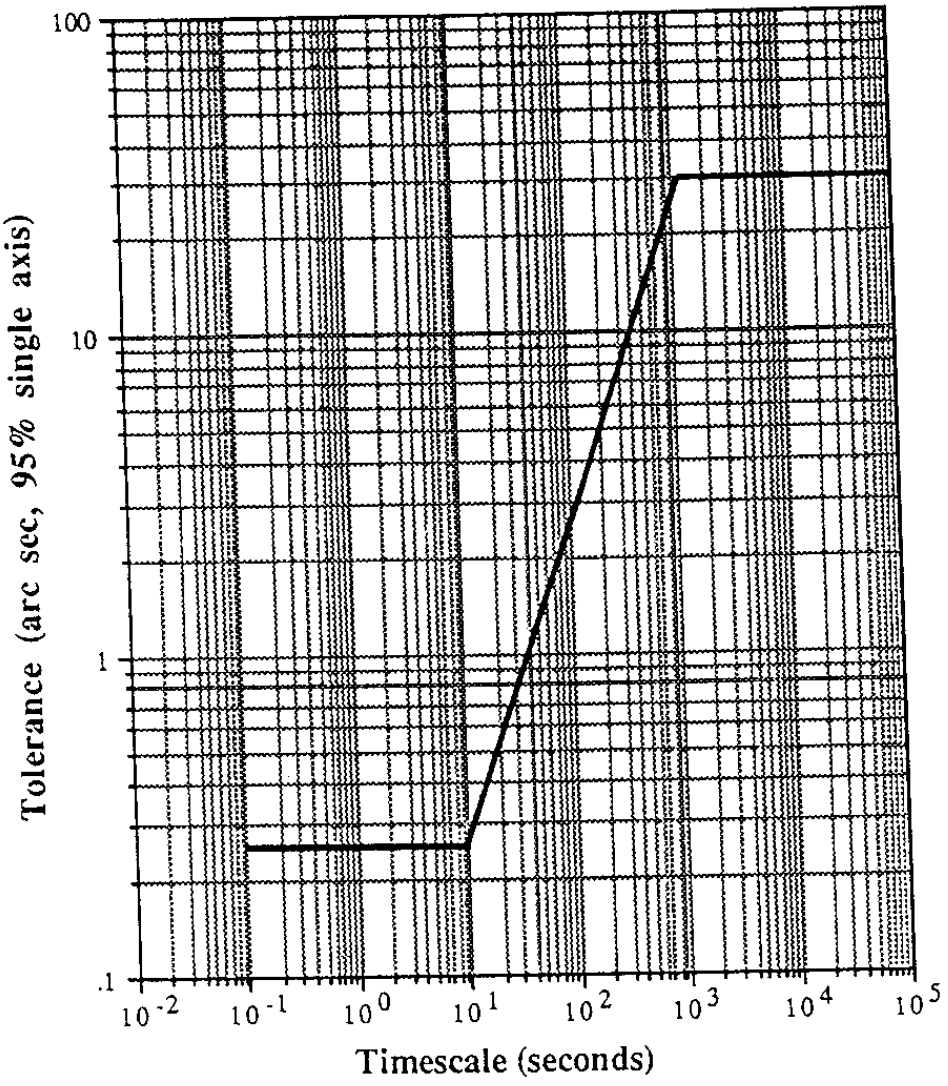
Timescale (seconds)	**Tolerance** (arc. sec, 95%, single axis)
0.1	0.25
1.0	0.25
10	0.25
100	2.5
120 (2 min)	3
1 000	30
10 000	30
36 000 (10 hr)	30
100 000	30

It is not feasible (given the processing and memory resources of the data processing electronics) to resample the detector pixel grid on a finer scale in order to compensate for the spacecraft rotation. The spacecraft rotation is therefore calculated, but no roll-correction is made to the time slices of the images before summing. The spacecraft roll therefore has the effect of causing blur at large
distances from the centre of roll (which can be specified to the tracking algorithm).

Intrinsically the upper limit of the blue detector exposure time is set by the time it takes to saturate the number of bits (24) in the image store. This would be 6.5×10^4 sec or 18 hours at 250 c/sec/pix, equivalent to the duration of the active portion of the orbit at the maximum counting rate. Because the telemetry requirement occurs only at the end of the exposure, long exposures make efficient use of the telemetry bandwidth available to the OM. As it stands at present, however, the roll specification limits the exposure time to ~3600 sec, depending on the characteristics of the roll. Further improvements to the roll translate directly into more efficient use of the telemetry bandwidth, allowing the acquisition of larger images or data at a higher time resolution, and images with higher spatial resolution at their boundaries.

In order to achieve high time resolution on selected areas of the field of view while at the same time fitting within the guaranteed telemetry bandwidth, the high time resolution windows have to be spatially restricted to a reasonable size, typically 8 arc sec square. For the current specification of the absolute pointing, it is clear that for all non-interactive observations it will be necessary to provide an image recognition algorithm within the instrument in order to centre the image within the small windows. Such an algorithm has been written and tested and has been shown to be robust. Entries from the Hubble Space Telescope guide star catalog are uplinked at the same time as the observing sequence commands.

Figure 3.4: Pointing Performance Goals



3.5 Interface Control Drawings

Full size copies of the interface control drawings are annexed only to the EID-Bs distributed to the spacecraft conctractor. These drawings are placed under configuration control by ESA and are to be regarded as the primary source of information. Reduced size (A3) are not annexed any more.

The following table specifies, for each interface control drawing, the OM drawing title, the OM drawing number and the ESA file number

Table 3.5

Unit	OM Drawings Number / Issue / Date	ESA File Number	Note
OM 1	5254-300-4 (TBC)	PX-0005/E	Interfaces with s/c in line with Dornier fax XM-DOR-302/ 96 ; 15.2.96 (A Rausch / J. Kroeker)
OM 2 (prime and redundant)	R39988 / C ; 22.9.1994	PX-0010 / B	
OM 3 (prime and redundant)	Not yet issued	None	Estimated mass: 2 X 1.1 Kg = 2.2 Kg

3.6 Instrument Allocated Mass

The mass allocated to the Optical Monitor instrument is 96.7 kg.

3.7 Instrument Estimated Mass

The total estimated mass of the instrument, including contingency, is 96.7 kg.

The estimated mass of each unit is specified on the relevant interface control drawing or, in case it is not yet issued, in table 3.5

3.8 OM 1 Telescope Unit Stiffness Characteristics

The first global resonance frequency (þ) of the OM 1 unit, in hard-mounted condition will be not lower than 60 Hz.

3.9 OM 1 Telescope Unit Strenght Characteristics

The OM 1 telescope unit will be designed to withstand limit loads as defined in the table below:

	Axial (g)	Lateral (g)	Rotational (rad/sec^2)
OM 1	15	10	500

4. THERMAL INTERFACES AND REQUIREMENTS

4.1 Temperature Limits in Space Environment

Unit	Operating (þC)		Minimum Switch-on (þC)	Non-Operating (þC)	
	Min.	Max.		Min.	Max.
OM 1	+ 16	+ 24	- 25	- 25	+ 55
OM 2	- 10	+ 40	- 25	- 25	+ 55
OM 3	- 10	+ 40	- 25	- 25	+ 55

4.2 Temperature Limits in Laboratory Environment

Unit	Operating (þC)		Minimum Switch-on (þC)	Non-Operating (þC)	
	Min.	Max.		Min.	Max.
OM 1	+ 0 (*)	+ 25 (*)	- 25	- 25	+ 55
OM 2	- 10	+ 40	- 25	- 25	+ 55
OM 3	- 10	+ 40	- 25	- 25	+ 55

(*) Some scientific performances will be degraded in this wider operating range.

4.3 Environment Requirements during Ground Storage and Transportation

Maximum temperature:
See maximum non-operating temperature of the relevant unit.
Minimum temperature:
See minimum non-operating temperature of the relevant unit.

Humidity: þ 60%
Pressure: 200 ÷ 1100 m bar

4.4 Temperature Bake-Out Limits

+ 80þC nominal, for a period of 24 hours (TBC).

4.5 Temperature Sensors

Unit	Sensor Read-out		Location	Type
	S/C	Instru.		
OM 1	2 (*)	16	S/C:Blue module Instru: Blue module; Telescope structure	S/C: YSI 44908 Instru: YSI 44908
OM 2	--	--	--	--

(*) Spacecraft powered sensor, procured by the Prime Contractor for the QM and FM models and integrated by the Instrument.

4.6 Heaters

Unit	Device Power		Location	Type
	S/C	Instru.		
OM 1	1(*)	16	S/C: TBD Instru: Blue module & telescope structure	S/C: RWR 80 Instru: RWR 80
OM 2	--	--	--	--

(*) Spacecraft powered heater, provided and integrated by the Instrument. The power dissipated by the heater is specified in para. 5.4

4.7 Thermal Schematic

Figure 4.7.a: Telescope Unit Thermal Links Schematic

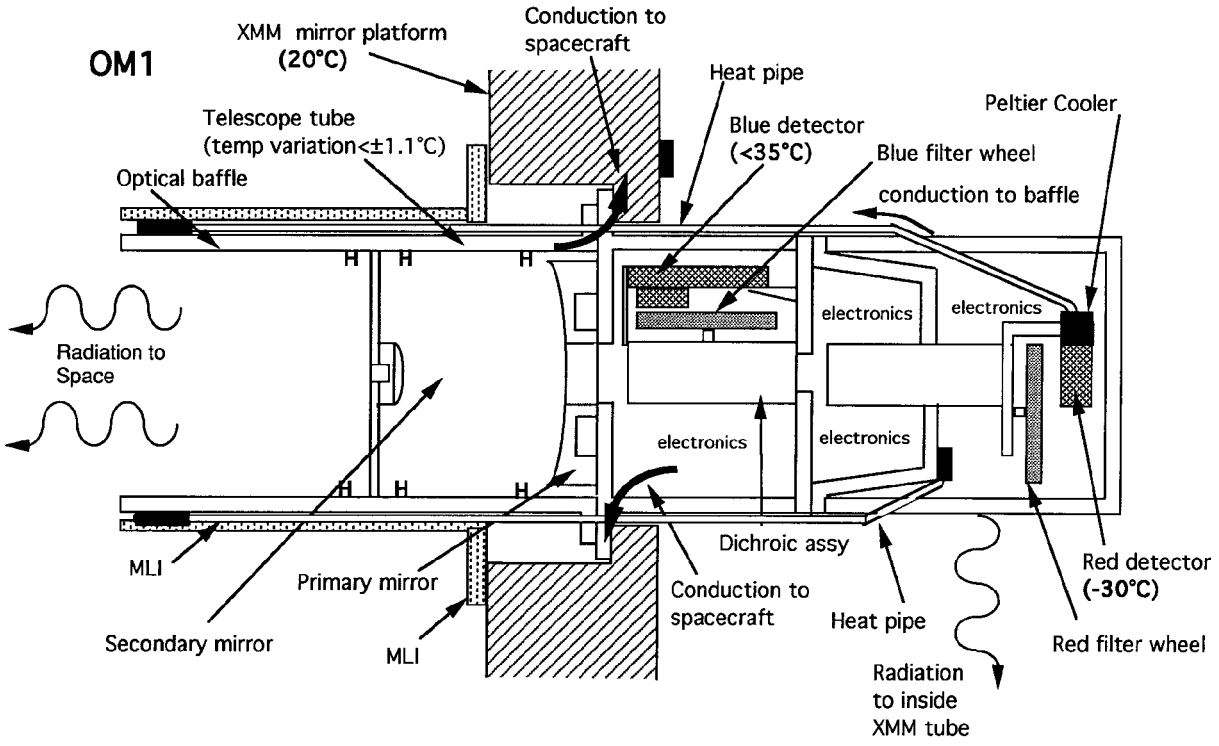


Figure 4.7.b: Telescope Unit Heat Flow Schematic

TBD

4.8 Thermal Control Requirements

The temperature difference among any 2 mounting points of the interface flange of the telescope unit shall not exceed 0.5þC.

The rate of change of temperature at the telescope unit temperature reference point shall not exceed 1.0þC/hr.

5. ELECTRICAL INTERFACES AND REQUIREMENTS

5.1 Spacecraft Electrical Resources Requirements Summary

Parameter	Signal Type	Basic Requirement (5)	Redundancy (6)	
			circuit	line
Power	+ 28 V power (1)	1	X	X
	+ 28 V power returns	1	X	X
	keep alive power	2		
	keep alive power returns	2		
	heater power	1	x	
	heater power return	1	x	
Synch	converter synchronisation (2)	2		
	converter synchronisation return	2		
Data	digital bus interface (3) (telemetry/telecommand)	1	X	
	analogue channels (double ended)	0		
	analogue channel (double ended) return	0		
	relay status monitor	0		
	relay status monitor return	0		
Telecommands	high level on/off commands	0		
	high level on/off commands return	0		
Temperature (7)	temperature sensor	2		
	temperature sensor return	2		
Pyro	pyrotechnic device	0		
DBU	DBU power supply (4)	1	X	
	DBU power supply return	1	X	

(1) Instrument power switching is executed in the s/c power subsystem.
(2) Both converter synchronisation signals are available simultaneously.
(3) Prime and redundant digital bus interface shall have the same terminal address.
(4) The active half of the DBU is powered from the instrument.
(5) Basic requirement: number of functions without redundancy.
(6) See EID-A para 5.8.6.
(7) See EID-B, para. 4.5

5.2 Instrument Power Distribution Block Diagram

TBD

5.3 Instrument Allocated Power

The power allocated to the Optical Monitor instrument is:

64 W average
83 W peak

5.4 Power Budget at End of Life

+ 28 V POWER (W)			
	OFF	**Maximum Average**	**Long Peak**
OM 1	7.0 (1) (TBC)	33.3	41.8
OM 2 active	0.0	11.8	11.8
OM 2 inactive	0.0	0.0	0.0
Total	7.0	45.1	53.6

Keep Alive Power (W)			
	OFF	**Maximum Average**	**Long Peak**
OM 1	0.0	0.0	0.0
OM 2 active	0.5 (2)	0.01 (2)	0.01 (2)
OM 2 inactive	0.5 (2)	0.5 (2)	0.5 (2)

The "active" OM2 refers to the one of the two redundant units which is powered up while the instrument is ON and the OM2 "inactive" is the un-powered unit

The OFF state includes the s/c powered heaters (see later section)

(1) S/C substitution heater power

(2) Keep-Alive Power

The power dissipation in the various modes at Beginning of Life is given below:

Unit	**OM1**				**OM2 (active)**		**OM2 (inactive)**		**DBU**
Power	KAL	+ 28 V	+ 28 V	+ 28 V	KAL	+ 28 V	KAL	+ 28 V	+ 28 V
Modes:	-	Minimum	Maximum	Peak	-	Min./Max./Peak	-	Min./Max./Peak	Min./Max./Peak
Off	0	0	7 (TBC)	0	0.25	0	0.25	0	0
Initial Status	0	1	1	1	0	10.7	0.25	0	1.1
Safe	0	20.8	32.3	40.8	0	10.7	0.25	0	1.1
Idle	0	21.8	33.3	41.8	0	10.7	0.25	0	1.1
Eng./Cal.	0	21.8	33.3	41.8	0	10.7	0.25	0	1.1
Science	0	21.8	33.3	41.8	0	10.7	0.25	0	1.1

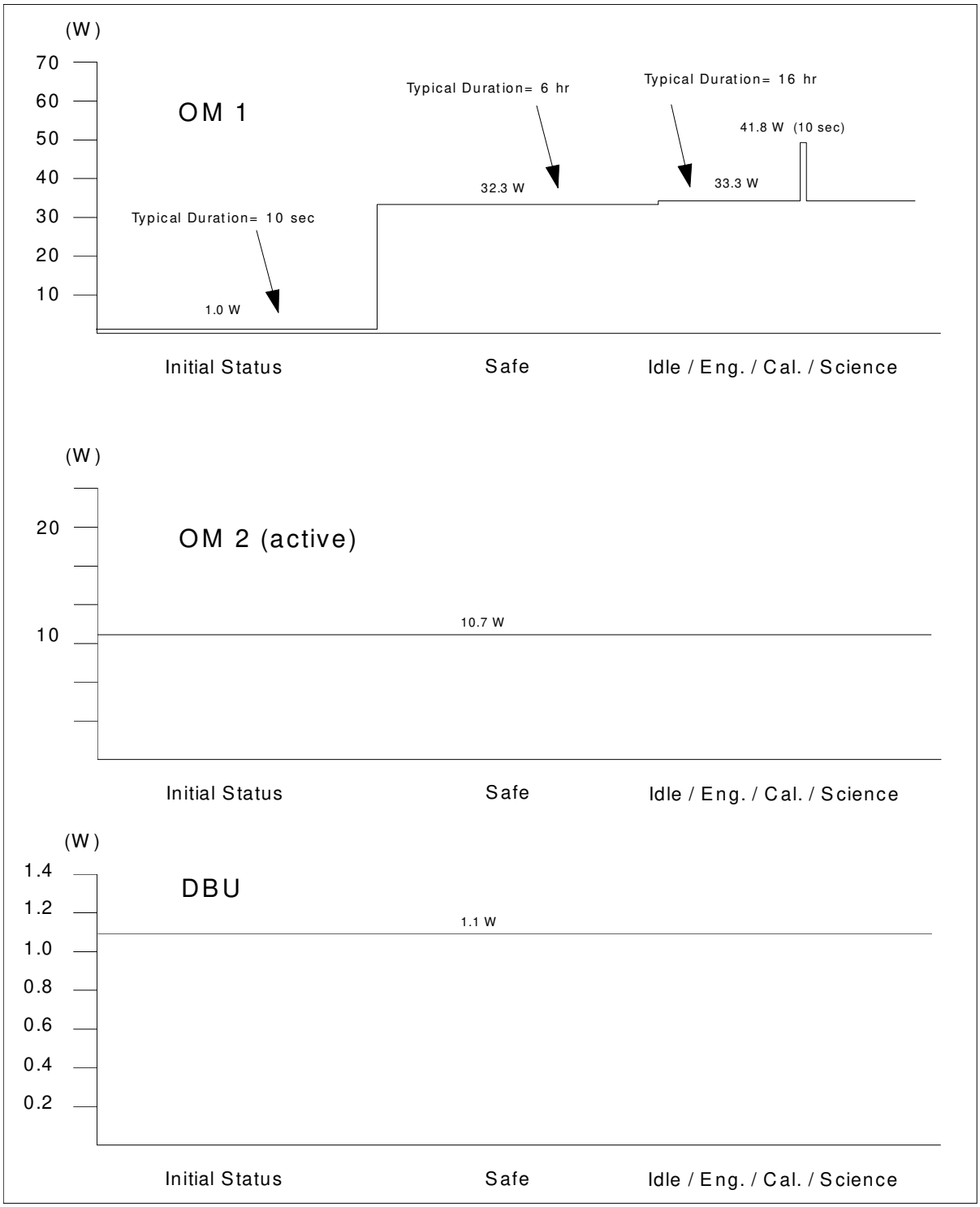
Peak : Peak to trough power averaged over 10 seconds

Note: It is assumed that mechanisms and heaters will not be energised simultaneously.

5.5 Power Consumption Profiles

The power consumptions profiles of the telescope unit, the digital electronics unit and the data bus unit in their various modes are shown in figure 5.5.

Figure 5.5: Telescope, Digital Electronics and Data Bus Units Power Consumption Profiles vs. Modes



5.6 Telecommands

5.6.1 Telecommands Requirements

DBI command rate = 1.7 Kbits/sec maximum, during observation.

5.6.2 Telecommand Description

Command packets will be formatted according to the XMM Packet Structure Definition document PX-RS-0032. The detailed list of commands is TBD.

5.7 Telemetry

5.7.1 Telemetry Requirements

Maximum Telemetry Rate : 8 kbits/sec, during observation

5.7.2 Telemetry Description

5.7.2.1 HK Telemetry

The housekeeping data will be provided in a single source packet repeated at a constant rate. The following housekeeping parameters are foreseen:

1) Instrument derived time;

2) Currents;

3) Voltages;

4) Temperatures;

5) Heaters (on/off status);

6) Positions (of moveable mechanics);

7) Switching configuration (relays, high voltage enables etc);

8) High voltage sensors (health, voltage and or current);

9) Packet counts (each uplink and downlink VT);

10) Errors (count and last error code);

11) Confirmations (last direct command packet ID and return code);

12) Modes (which detectors are running, what digital processing and instrument control electronics processes are active);

13) Subsystems status' (a few bits indicating health and activity for each subsystem);

14) Tracking status (terse report on lock condition and drift vector status from the data processing electronics processing);

15) Science parameters (minimal).

Housekeeping telemetry points will be sampled as follows:

A: every 8 seconds, all categories except 2,3,4,5 and 15 above;

B: every 16 seconds, 2 and 3 above;

C: every 64 seconds, 4, 5 and 15 above.

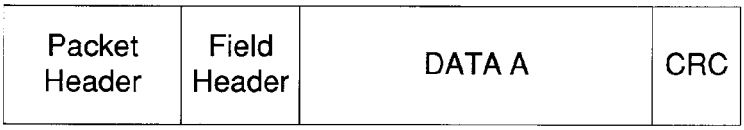
Housekeeping data will be contained in three source packet types with constant length and format. With the sampling scheme above a basic packet format A will be queued for collection every 8 seconds. Every other packet (16 seconds) will contain a format A+B. One in eight packets (64 seconds) will contain A+B+C.

Figure 5.7.2.1 describes the three types of packets.

Housekeeping data rate will be limited to 100bps.

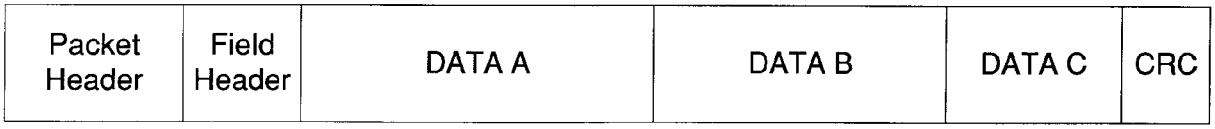
Figure 5.7.2. Housekeeping Telemetry Packets

8 Sec Packet



16 Sec Packet

64 Sec Packet



5.7.2.2 Science Telemetry

Science telemetry is categorised as below:

1) "Image Mode" data;
2) "Fast Mode" data;
3) "Brightstar and Threshold" data

In addition, ancillary information will be telemetered:

4) "Field Acquisition" data;
5) "Reference Frame" data;
6) "Tracking History" data;
7) "Window Parameter" data (both detector and observational);
8) "Engineering Mode" data;
9) "Digital Processing Electronics Software Log Diagnostic" data.

5.7.2.3 Engineering Telemetry

TBD

5.8 Electrical Interface Circuits

5.8.1 +28 V Power Interface

5.8.2 Keep Alive Power Interface

5.8.3 Converter Synchronisation Interface

5.8.4 Heater Power Interface

5.8.5 Digital Bus Interface

5.8.6 Analogue Data Channel Interface
N.A.

5.8.7 Relay Status Monitor Interface
N.A.

5.8.8 Telecommand (high level on/off) Interface
N.A.

5.8.9 S/C Powered Temperature Sensors Interface
TBD

5.8.10 DBU Power Interface
TBD

5.8.11 Pyro Device Interface
N.A.

5.9 Connectors and Harness Interfaces

5.9.1 OM 1 Connector List and Pin Function List

5.9.2 OM 2 Connector List and Pin Function List

6. EMC AND ESD INTERFACES AND REQUIREMENTS

6.1 Susceptibility Requirements

The analogue processing chain is most sensitive in the 10KHz - 20MHz.

6.2 Frequency Plans for Units Emission

þ 0.1 Hz	Heater switching
100 Hz - 1 kHz	Stepper motor drive (*)
100 kHz - 1 MHz	ICB - 3M screened cable: clock 500 KHz, data at 250 KHz, 125 KHz etc; converters for HV at 200 Khz; main power converters at 65.5 KHz.
1 MHz - 10 MHz	Digital clocks inside boxes 1, 2.5, 4, 5, 8, 10 MHz,data I/F at 5 MHz, data at 2.5 MHz; CCD clock at 10 MHz.
10 Mhz - 20 MHz	Cystal oscillator frequencies at 16 and 20 MHz.

(*) Stepper motor drive is in the band 100Hz to 1KHz as stated. It will be driven with the first few pulses ramping up to approx. 420 Hz and ramp down at the end of the movement.

Figure 6: Grounding Block Diagram

7. TRANSPORTATION, HANDLING, CLEANLINESS AND PURGING REQUIREMENTS

7.1 Transportation Requirements

7.1.1 Telescope Unit

For this unit a special transport container will be made available.

7.1.2 Digital Electronics Units and Interconnecting Harness Unit

For these units standard containers will be made available.

7.2 Handling Requirements

7.2.1 Telescope Unit

The telescope unit is an optical instrument which will require careful handling. It is too massive to be lifted by a single person and will be delivered with a MGSE crane. Carrying handles will be supplied to permit the lifting of the unit by more than one person or by means of the crane.

Whenever possible the telescope unit must remain inside its transportation container with gas purge MGSE connected. Outside of the transportation container, the telescope unit shall be orientated within its MGSE so that it is facing downwards. At no stage shall the telescope unit be supported at any point except at its mounting interface or carrying handles. At all times except were absolutely necessary the instrument end cap and any other caps shall be retained in place until the final stages of integration. Such caps will be marked with red tags.

7.2.2 Digital Electronics Units and Interconnecting Harness Unit

For these units no special handling requirements are foreseen.

7.3 Cleanliness Requirements

7.3.1 Telescope Unit

The cleanliness requirements for the telescope unit will be severe, particularly in the UV, if the telescope unit is to reach its full potential sensitivity.

The sensitivity is degraded in two ways:

1. attenuation by molecular contaminants;

2. scattered background contributed by particulate contamination (dust).

The effect of the molecular contamination can be seen in figure 7.3.1. In order for the sensitivity to be degraded by less than 20% over the wavelength range 160 nm to 1000 nm, a total absorption coefficient þ 10^{-7} g/cm^2 at end of life is required. This is consistent with the requirement placed in the EID-A document.

The effects of scattering by particulate contamination and microroughness in the optics are severe because of the extremely low background in the space environment and the modest baffle length available on the telescope unit. The fraction of the scattering budget to be assigned to particulate contamination is 50%. The cleanliness of the optical surfaces is 300 ppm in order to comply with the envelope of the permitted bi-directional reflectance distribution function of the contaminated surface.

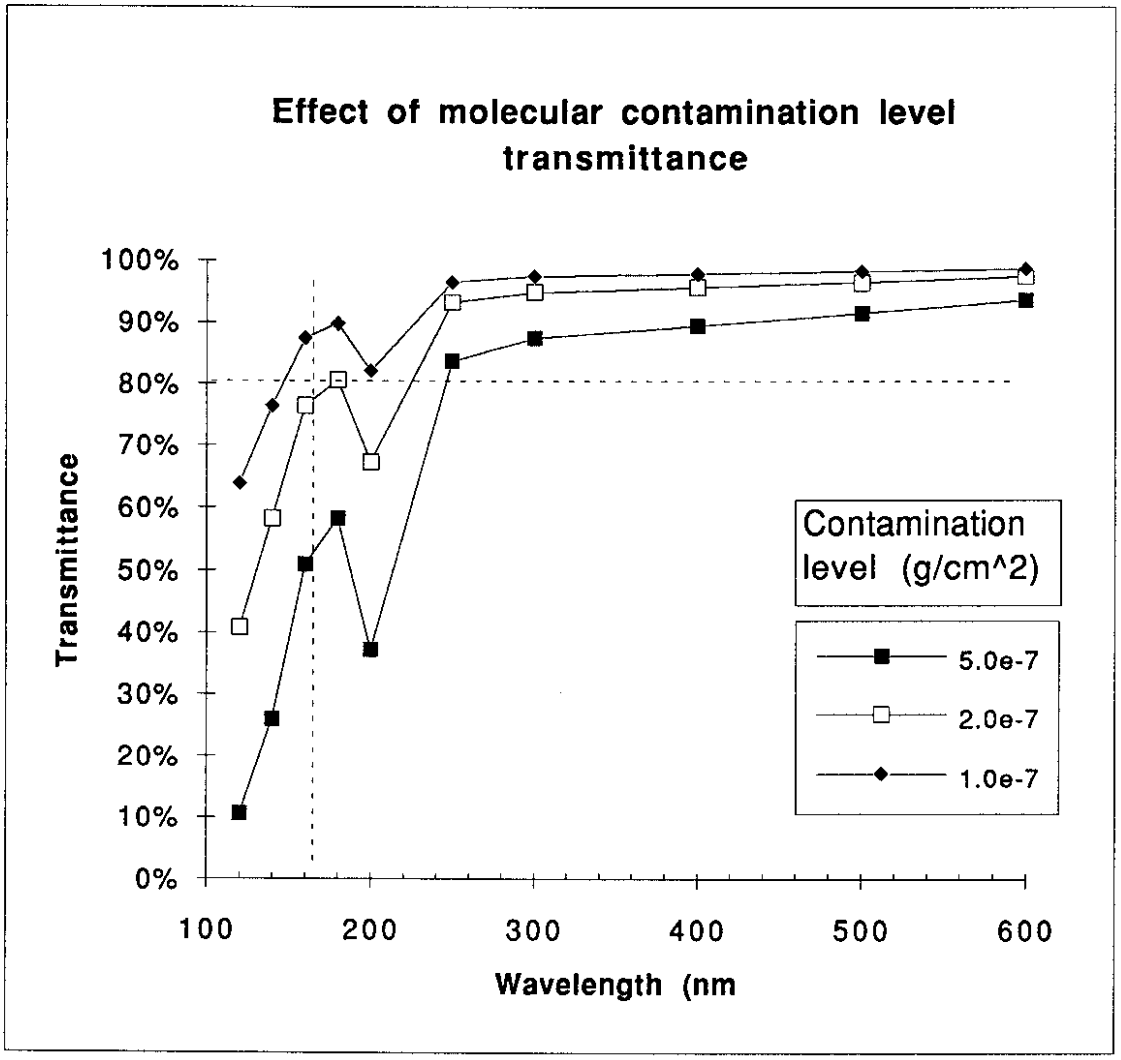
In order to minimise the effect of these contaminants, careful choice of materials will be exercised and close attention paid to outgassing paths and handling and cleanliness procedures during integration and before launch.

7.3.2 Digital Electronics Units and Interconnecting Harness Unit

For these units no special cleanliness requirements are foreseen.

Figure 7.3.1: Molecular Contamination Effects over Transmittance

Wavelength (nm)	Absorption Coefficient (1/(ng/cm^2))	Contamination level(g/cm^2) 5.0e-7	2.0e-7	1.0e-7
120	0.0005	11%	41%	64%
140	0.0003	26%	58%	76%
160	0.00015	51%	76%	87%
180	0.00012	58%	81%	90%
200	0.00022	37%	67%	82%
250	0.00004	84%	93%	96%
300	0.00003	87%	95%	97%
400	0.000025	89%	96%	98%
500	0.00002	91%	96%	98%
600	0.000015	93%	97%	99%



7.4 Purging Requirements

7.4.1 Telescope Unit

The telescope unit trickle purge will be supplied by the purge MGSE through the instrument end cap so that the purge flow is first to the telescope, then the blue detector bay before reaching the remainder of the unit. After the instrument end cap is removed for the closing of the payload module door, purge must be re-established so that the flow is, as before, first through the telescope section. The telescope unit shall be purged continuously by trickle purge until as late as is feasible, if possible continuing after integration within the spacecraft shroud, and broken only at launch.

The spacecraft contractor will be responsible for the monitoring of the purge MGSE and its correct operation. Logging of the monitoring activities and of the purge gas quality on a regular basis will be a requirement.

7.4.2 Digital Electronics Units and Interconnecting Harness Unit

For these units there are no purge requirements foreseen.

8. GROUND AND FLIGHT OPERATION REQUIREMENTS

8.1 Ground Operations

8.1.1 Assembly, Integration and Verification

On delivery, the open end of the telescope unit will be closed by an end-cap to maintain the cleanliness of the optics. This cap will carry also a small optical stimulator operating only over part of the telescope aperture, to provide a simulated starfield. This will be used for end-to-end testing of the instrument to ensure that no gross deterioration has occurred. It will contain a beta-source which will provide a stable, low level illumination without any need for control or power and it will remain permanently on. Optics in the telescope unit will produce a parallel beam. After integration in the satellite a similar stimulator should be provided by the spacecraft contractor on the inside of the spacecraft door.

After integration in the S/C a short functional test (SFT) and an instrument functional test (IFT) are foreseen in order to monitor the health of the instrument and to check the s/c interfaces. Both tests will be safe to execute with or without cooling to the radiator, in air or in vacuum and with the instrument end-cap or the spacecraft door open or closed. The tests will use the internal flat field flood lamps on each detector and the star simulator on the inside of the end-cap or the spacecraft door.

8.2 Flight Operations

The table below summarises the instrument modes during flight operations.

Mission Status	**Permitted Mode**
LEOP	OFF
Switch-on	INITIAL STATUS þ SAFE (TBC)
Slew	SCIENCE
Perigee	SAFE
Eclipse	OFF
Loss of communication to the OBDH	SAFE
AOCS Alert	SAFE
Science Exposure	SAFE, IDLE, ENGINEERING & CALIBRATION, SCIENCE
Diagnostic	SAFE, IDLE, ENGINEERING & CALIBRATION, SCIENCE
Calibration	SAFE, IDLE, ENGINEERING & CALIBRATION, SCIENCE

8.2.1 Avoidance Angles

Source	Angles	State	Comments
Sun limb	>70þ	Mode commandable	1) No direct sunlight to reach telescope baffle entrance 2) Inside of spacecraft door black and if possible with baffle vanes 3) Careful attention to scattering sources on spacecraft
	< 65þ	Safe mode	Safe mode triggered by spacecraft command on OBDH bus and, as backup, by internal monitoring signal. Transition will take 10 sec.
Earth limb	>35þ	Mode commandable	
	<35þ	Safe Mode	Safe mode triggered by internal monitoring signal. Transition will take 10 sec.
Moon limb	>35þ	Mode commandable	
	<35þ	Safe Mode	Safe mode triggered by internal monitoring signal. Transition will take 10 sec.

8.2.2 Violation of the Sun Avoidance Angle Constraint

The instrument will be designed to survive limited exposure to the Sun and Earth while in Safe Mode. In the case of the Sun, the safe duration will be <60 sec, and in the case of the Earth, the safe duration will be <TBD sec. Safe mode will be triggered by spacecraft command on the OBDH bus and, as backup, by internal monitoring signal on the blue detector. The transition to Safe Mode will take 10 sec.

8.2.3 Calibration

In order to define requirements for acquiring fields, the calibration and verification phase of the mission will include measures to examine the pointing directions of the OM, EPIC and RGS. Constraints on positioning targets will include the measured offsets between OM and EPIC/RGS, the blank ribs in the EPIC images, orientation of the detectors with respect to CCD charge transfer directions, bad spots in the performance on any instrument etc. With time, mission analysis should also reveal the likely thermal changes which may impact the co-alignment of the detectors, and this may need to be considered in the choice of pointing direction for field acquisition. Should an element of the blue detector system fail, it is understood that the redundant system will be employed. Should this occur well into the mission, the requirement to perform a new set of calibration observations will impede the other instrument operation efficiency. Hence it is suggested that the normal calibration and verification phase include some minimal observations with the redundant system to ensure confidence in the initiation of the redundant system observations can be made with little distraction (e.g. pointing offsets, optimal focusses etc. are known). Contingency plans for using normal star fields (based on accumulated experience with the primary system) for calibrating the redundant system will be considered.

In-orbit calibrations will include both internal stimulation to test functionality and individual performance parameters, and astronomical calibrations to determine sensitivities, resolutions

and spatial distortions.

Spatial distortions may be mapped by observing a number of well-separated point sources of known position. This allows a measurement of the distortion as a coarse function of position.

An internal source will be used to illuminate the detectors to obtain a calibration flat field. This need not necessarily be flat, only constant in spatial distribution from one stimulation to the next. It will be variable in coarse intensity steps. This field will be used also to recalculate the centroiding lookup table in the blue detector from
time to time.

Calibration against astronomical standards will require a wide range of measurements if the full dynamic range is to be confidently mapped. This will not necessarily entail more than a few special pointing directions.

8.2.7 Early Operations

During launch the instrument will be off. In order to move the mechanisms in their reference position, switch-on of the instrument should occur before the spacecraft door is opened. This will result in the instrument moving into an INITIAL STATUS mode (cfr. para 2.9.2), where basic checks on the health of the instrument can be made. Execution of a 3rd stage load (cfr. figure 2.10) will then be permitted (TBC pending the thermal modelling with the spacecraft door closed), moving the instrument into SAFE mode. After sufficient outgassing has occurred, further transitions can be made to IDLE, ENGINEERING & CALIBRATION modes in order to check operations using the stimulator on the inside of the spacecraft door. Performance will not be nominal because the passive radiator at the front of the baffle will not be operating.

9. DELIVERABLE MODELS AND GSE

9.1 Structural Thermal Model

9.1.1 Telescope Unit
No structural thermal model will be delivered.

9.1.2 Digital Electronics Units and Interconnecting Harness Units
The structural thermal model will consist of two digital electronics units (OM2) and two interconnecting harness units (OM3).
The STM for the two OM2 units will be mechanically and thermally representative of the respective flight units. The structural response characteristics will not be simulated. The electronics inside each unit will be replaced by mass dummies. Heater(s) will be included to simulate the power dissipation vs all instrument modes. Before delivery these units will be subjected to an environmantal test programme to qualification levels.
The STM units for the two OM3 will be mechanically representative of the flight harness, but hi-rel components will not be used. Functionally the harness units will be used to control the heater(s) inside each STM OM2 units.

9.1.3 Mechanical Ground Support Equipment
Suitable mechanical ground support equipment will be supplied for safe transport and storage of the STM units.

9.1.4 Electruical Ground Support Equipment
TBD

9.1.5 Optical Ground Support Equipment
No optical ground support equipment will be suppliedfor the STM units.

9.2 Engineering Qualification Model

9.2.1 Telescope Unit

The EQM model will be actually an engineering model electrically and functionally representative of the flight model unit. Electrical components will be thermally and vacuum rated. The engineering model will not contain any optical element, telescope or baffle. It will only consist of the prime channel.

9.2.2 Digital Electronics Units and Interconnecting Harness Units

The EQM model will consist of only one OM2 unit and the related OM3 unit. The OM2 unit will be flight configuration but it will partly contain commercial grade components which will be thermally and vacuum rated. Prior to delivery the EQM will be subjected to a complete functional and environmental (i.e. thermal and vibration) qualification test programme. The EQM will be delivered with the associated on-board s/w as well as the related documentation.

9.2.3 Mechanical Ground Support Equipment

Suitable mechanical ground support equipment will be supplied for safe transportation and storage of each EQM units. Nitrogen purge equipment will be provided during transportation and before, during and aftre integration into the After use some MGSE (e.g. handling tools) shall be returned to be refurbished for the FM model.

9.2.4 Electrical Ground Support Equipment

A complete set of EGSE, as described in para 2.8.1, will be delivered with the EQM.

9.2.5 Optical Ground Support Equipment

No OGSE will be supplied.

9.3 Flight Model

One full set of units will be delivered. Prior to delivery the flight model units will be subjected to the full acceptance and verification test programme.

9.3.1 Mechanical Ground Support Equipment

Mechanical ground support equipment will be supplied to allow safe transportation, and storage of each FM unit. Nitrogen purge equipment will be provided during transportation and before, during and aftre integration into the After use some MGSE (e.g. handling tools) shall be returned to be refurbished for the FM model.

9.3.2 Electrical Ground Support Equipment

The EGSE, supplied with the EQM, will be used for the FM.

9.3.3 Optical Ground Support Equipment

No OGSE will be supplied.

9.4 Flight Spare Model

9.4.1 Telescope Unit

No flight spare model will be supplied at unit level; spares will be held at component and sub-unit level.

9.4.2 Digital Electronics Units and Interconnecting Harness Units

The EQM of the OM2 unit will be refurbished and become the flight spare unit.
No flight spare unit for OM3 will be delivered.

9.4.3 Mechanical Ground Support Equipment

Mechanical ground support equipment will be supplied to allow safe transportation, integration and handling of each FS unit.

9.4.4 Electrical Ground Support Equipment

The EGSE, supplied with the FM, will be used for the FS.

9.4.5 Optical Ground Support Equipment

No OGSE will be supplied.