

COM DEV

April 26, 1995
5093-KP4009

Canadian Space Agency
Space Science Program
c/o National Research Council
Room 1016
100 Sussex Drive
OTTAWA ON
K1A 0R6

Attention: Roger Colley

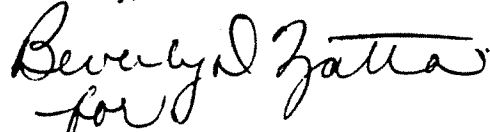
Reference: MOPITT Main Contract
9F007-2-6527/01-SR

Subject: MOPITT CDR Package

In accordance with the above-referenced Contract, please find enclosed 2 (two) copies of MOPITT CDR Package for your review and comment.

Also included is a complete listing of documents which you will receive during the next two weeks.

Yours truly,



Kate Peister
Sr. Administrator

cc:	J. Drummond	U of T
	J. Gervin	GSFC
	R. Boisselle	PWGSC
	Roger Tong	M9
	Jim Moffat	U3

DOCUMENT TRANSMITTAL



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TO: NASA - Goddard Space Flight Center REF.: 5093/KP-4009

ATTN: Dr. Janette Gervin

DATE: 26 April 1995

ITEM NO.	QTY.	SUPPLY CODE*	DOCUMENT NO.	REV. STATUS	DESCRIPTION
1	1	R/A	EQS/MOP/113360/001	P3	MOPITT Instrument Specification
2	1	R/A	DVD/MOP/113360/001	P0	MOPITT Requirements Traceability Document
3	1	R/A	EQS/MOP/113364/402	P2	MOPITT Software Specification Instrument Controller Module
4	1	R/A	EQS/MOP/5093/001/SED	P5	MOPITT BCU System Specification & Requirements Contract End Item
5	1	R/A	SDD/MOP/113364/400	P1	MOPITT Software Design Description Instrument Controller Module
6	1	R/A	PAP/MOP/5093	-	MOPITT Performance assurance Implementation Plan
7	1	R/A	TNO/MOP/113366/002	P0	MOPITT Instrument Dynamic and Stress Analysis
8	1	R/A	TNO/MOP/113366/001	-	MOPITT Instrument Detailed Thermal Model

Originator: Kate Peister, Contracts Department

- * The letter in this column indicates purpose for supplying the listed documents:
I - Information, R - Review, A - Approval

Receipt Acknowledged: _____

Signature
M6

Date

Int. Distr.: W. Dooling/K. Orr

MOPITT CDR Documents List

12/04/86

Document Description	Document No.	Status	Deliverable/CSA	Deliverable/UCI	Deliverable/MSA
Specifications					
MOPITT Instrument Specification	EQ8/MOP/1336/0001	No Update Req'd		1	1
MOPITT Requirements Traceability Document	DYD/MOP/1336/0001	No Update Req'd			
SPM Requirements Specification for	EQ8/MOP/1336/304	No Update Req'd		1	1
TCMM Requirements Specification	EQ8/MOP/1336/306	No Update Req'd			
ICM Requirements Specification	EQ8/MOP/1336/303	No Update Req'd			
PLDM Requirements Specification	EQ8/MOP/1336/310	No Update Req'd			
SCDM Requirements Specification	EQ8/MOP/1336/308	Update	2		
PDM Requirements Specification	EQ8/MOP/1336/311	No Update Req'd			
PCDM Requirements Specification	EQ8/MOP/1336/305	No Update Req'd			
LMC Requirements Specification	CD100782-00-360	No Update Req'd			
PLC Requirements Specification	MOPITT-TD-0018	No Update Req'd			
Cooler Drive Requirements Specification	EQ8/MOP/1336/2702	Update	2		
SCC Requirements Specification	EQ8/MOP/1336/2701	Update	2		
Detector Cold Optics Requirements Specification	EQ8/MOP/1336/8001	Update	2		
Calibration Sources Requirements Specification	EQ8/MOP/1336/7701	Update	2		
PSM Requirements Specification	EQ8/MOP/1336/801	No Update Req'd			
Optical Subsystem Requirements Specification	EQ9/MOP/1336/1100	Update	2		
Software Specification for the ICM	EQ8/MOP/1336/4402	Update	2	1	1
BCU Requirements Specification	EQ8/MOP/5083/001/RED	No Update Req'd		1	1
Design Descriptions					
Instrument Design Description	DDDMOP/1336/001	Update	2		
Software Design Description	SDDMOP/1336/4400	No Update Req'd		1	1
SPM Design Description	DDDMOP/1336/304	Update	2		
ICM Design Description	DDDMOP/1336/303	Update	2	1	
TCMM Design Description	DDDMOP/1336/308	Update	2	1	
SCDM Design Description	DDDMOP/1336/308	Update	2	1	
PLDM Design Description	DDDMOP/1336/310	Update	2	1	
Cooler Subsystem Design Description	DDDMOP/1336/2700	Update	2		
Chopper Design Description	DDDMOP/1336/1102	Update	2	1	
LMC Design Description	CD100488-01-387	Update	2	1	

Document Description	Document No.	Status	Delivered/CBA	Delivered/LOT	Delivered/ASBA
Interface Documents					
Instrument Internal ICD	ICD/MOP/113360/002	Update	2	1	
Software ICD	KCD/MOP/113384/400	Update	2	1	
PA Documents					
PAP	PAP/MOP/5093	Update	2		
Hazard Control Logbook	CD100410-01-387	Update	1		
Safety Assessment Report	CD100411-01-389	Update	1		
As Designed Configuration List		Update	1		
As Designed EEE Parts List	DCI/MOP/5093/001	Update	1		
Declared Materials List	DML/MOP/5093/001	Update	1		
Declared List of Processes	DLP/MOP/5093/001	Update	1		
FMCA	FME/MOP/113361/100	Update	2		
Critical Items List (including Linked the Items List)	CD100414-01-342	Update	1		
Continuation Control Plan	PLN/MOP/113360/005	Update	2	1	
EMC Control Plan	EMC/MOP/113360/001	No Update Req'd	2	1	
Configuration Control Plan	RCS/MOP/5093/002	Update	2		
Subcontractor PA requirements	ROS/MOP/5093/001	Update			
Analysis Documents					
Instrument : Dynamic and Stress Analysis	TNOM/MOP/113368/002	No Update	2	1	
Instrument : Thermal Analysis	TNOM/MOP/113386/001	Update	2	1	
Optical Analysis	Hughes Letz	No Update			
Radiometric Analysis		Update	1	1	
Instrument : EMC Analysis		Update	2	1	
Worst Case Analysis : Interface Signals	WCA/MOP/113381/100	Update	2		
Procedure Plans					
Instrument Verification Plan	PLN/MOP/113380/002	Update	2	1	
Instrument Verification and Test Procedure		Update		1	
Instrument Integration Plan		Update	2	1	
Software Management Plan	8MP/MOP/113384/400	Update	2	1	
Software Test Procedure	TPR/MOP/113384/400	No Update	2	1	

**MOPITT INSTRUMENT
SPECIFICATION**

EQS/MOP/113360/001



328 Urquhart Avenue, RR #11, Moncton, New Brunswick, E1C 9N1

MOPITT

PRELIMINARY

PREPARED BY:

Sign

Name: J. Hackett

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Function:

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MOPITT INSTRUMENT SPECIFICATION

CADM RELEASE

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PROJ. NO. 5093

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CAGE CODE 38101

A.

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SHEET ISSUE RECORD

All pages affected by the current ECN reflect the present document revision level.

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1.0

SCOPE

This specification establishes the performance, design, development, and test requirements for the Measurements Of Pollution In The Troposphere (MOPITT) Instrument.

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2.0 DOCUMENTS

2.1 Applicable Documents

The following documents form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement, except as defined by Section 3.8 of this document. Copies of specifications, standards, and publications required by suppliers in connection with specified procurement functions should be obtained from the contracting agency or as directed by the contracting officer.

The following documents of the exact issue shown are applicable to this document:

<u>Reference</u>	<u>Doc. No.</u>	<u>Title</u>
AD1	420-03-02	EOS General Instrument Interface Specification (GIIS), Rev. A, Change 03, April 11, 1994
AD2	421-12-15-02	Unique Instrument Interface Document (UIID), Rev. A, Change 01, June 23, 1994
AD3	420-05-01	Performance Assurance Requirement (PAR) for EOS General Instrument, November 30, 1989, as appended by CSA in 005SR.9F007-2-6527/A.
AD4	N/A	MOPITT Mission Description Document, October 30, 1993
AD5	CD100401-01-352	MOPITT Performance Assurance Implementation Plan
AD6	005SR.9F007-2-6527/A	Statement of Work (for the) Detailed Design and Qualification Phase of the MOPITT Instrument.

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2.2

Reference Documents, Standards and Specifications

The following documents form a part of this specification for reference and information use only. They do not explicitly define requirements in the instrument as delineated herein, unless specifically indicated in this document.

2.2.1

Reference Documents

The following documents are referenced in this document:

<u>Reference</u>	<u>Doc. No.</u>	<u>Title</u>
RD1	20008850	Interface Control Drawing, Top Level, Earth Observing System AM Spacecraft to Measurement of Pollution in the Troposphere ¹
RD2	PN20005869	EMC Control Plan for the EOS-AM Spacecraft, 15 January 1993
RD3	ICD/MOP/113360/002	MOPITT Instrument Internal Interface Control Document
RD4	DDD/MOP/113360/001	MOPITT Instrument Design Description
RD5	PLN/MOP/113360/002	MOPITT Verification Plan
RD6	GE 220008501	EOS General Interface Specification Handbook, Rev 1, 13 March 1991
RD7	CD 100404-01-365	MOPITT Contamination Control Plan
RD8	EMC/MOP/113360/001	MOPITT Instrument EMC Control Plan
RD9	N/A	Dave S. Steinberg, <u>Vibration Analysis for Electronic Equipment</u> , (New York: John Wiley & Sons, 1988), p. 409

¹ Including lower level ICDs referenced in the top level document; 20008851 Mechanical ICD Drawings, 20008852 Mechanical ICD Tables, 20008853 Thermal ICD, 20008854 Electrical ICD Schematic, 20008855 Electrical ICD Tables, 20008856 Integration and Test ICD, 20008857 Command and Data Handling ICD (sometimes called Command and Telemetry ICD)

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RD10		MOPITT Integration Plan
RD11	DVD/MOP/113360/001	MOPITT Requirements Applicability and Traceability
RD12		MOPITT IFOU
RD13	SDD/MOP/113364/400	MOPITT Software Design Description ICM
RD14	ICD/MOP/113364/400	MOPITT Software Specification Interface Control Document
RD15	EQS/MOP/5093/001/SED	Bench Checkout Unit Contract End Item Specification
RD16		Memo "Preliminary Study of MOPITT Coldplate Limits", June 10, 1993
RD17		Memo "MOPITT Torque Margins", July 4, 1994, J. Hackett
RD18		MOPITT Packing, Storage and Shipment Procedure

2.2.2 Reference Standards

The following standards are referenced in this document:

EIA RS-422-A	Electrical Characteristics of Balanced Voltage Digital Interface Circuits
GSFC PPL-20	GSFC Preferred Parts List
NPRD-3	Non-Electronic Parts Reliability Data
MIL-HDBK-217E	Reliability Prediction for Electronic Equipment
MIL-STD-490	Specification Practices
MIL-STD-975	NASA Standard Electrical, Electronic, and Electro-mechanical (EEE) Parts List
MIL-STD-1553B	Military Standard Aircraft Internal Time Division Command/Response Multiplex Data Bus

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MIL-STD-1576

Military Standard Electroexplosive Subsystem Safety
Requirements and Test Methods for Space Systems

MIL-STD-454J

Standard General Requirements for Electronic Equipment

MIL-STD-1472C

Human Engineering Design Criteria for Military Systems,
Equipment and Facilities

2.2.3

Reference Specifications

The specifications which define the major components comprising the Instrument are listed in
Table 3.1.1.2-2.

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3.0 REQUIREMENTS

This section describes the MOPITT Instrument functional, performance, design, development and test requirements.

3.1 MOPITT Instrument Definition

The MOPITT Instrument is a space based infrared (IR) radiometer that uses gas correlation spectroscopy to detect carbon monoxide and methane gases in the Earth's Troposphere. The instrument will be launched on NASA's Earth Observing System AM1 Spacecraft (EOS AM1 S/C). A detailed description of the MOPITT Instrument is provided in reference RD4.

The MOPITT Instrument will operate in essentially two system configurations;

- integrated to EOS AM1 S/C which provides the necessary interfaces for power, control, telemetry, thermal path, structural path and FOV (as shown in Figure 3.1-1).
- a stand alone instrument with customized GSE which supports complete operation of the Instrument (as shown in Figure 3.1-2).

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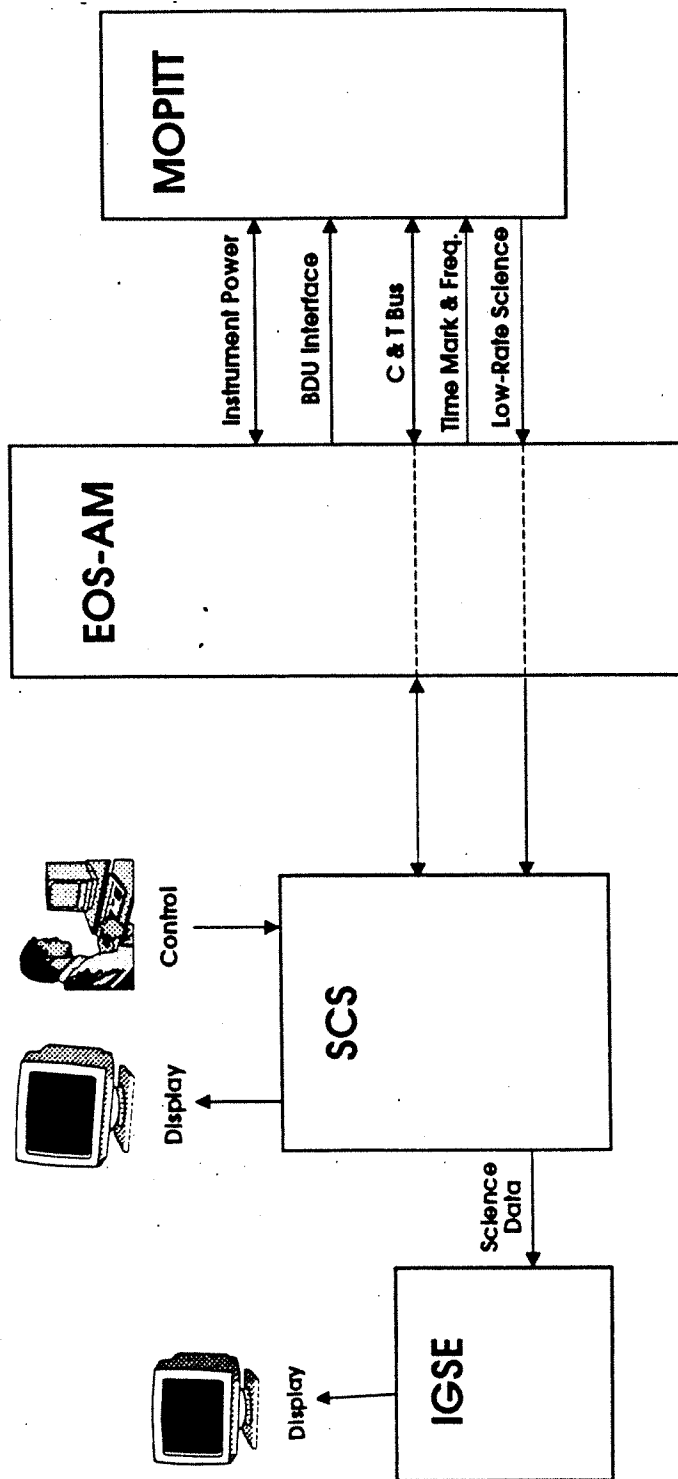


Figure 3.1.1-1: Functional Diagram of MOPITT Instrument On Spacecraft

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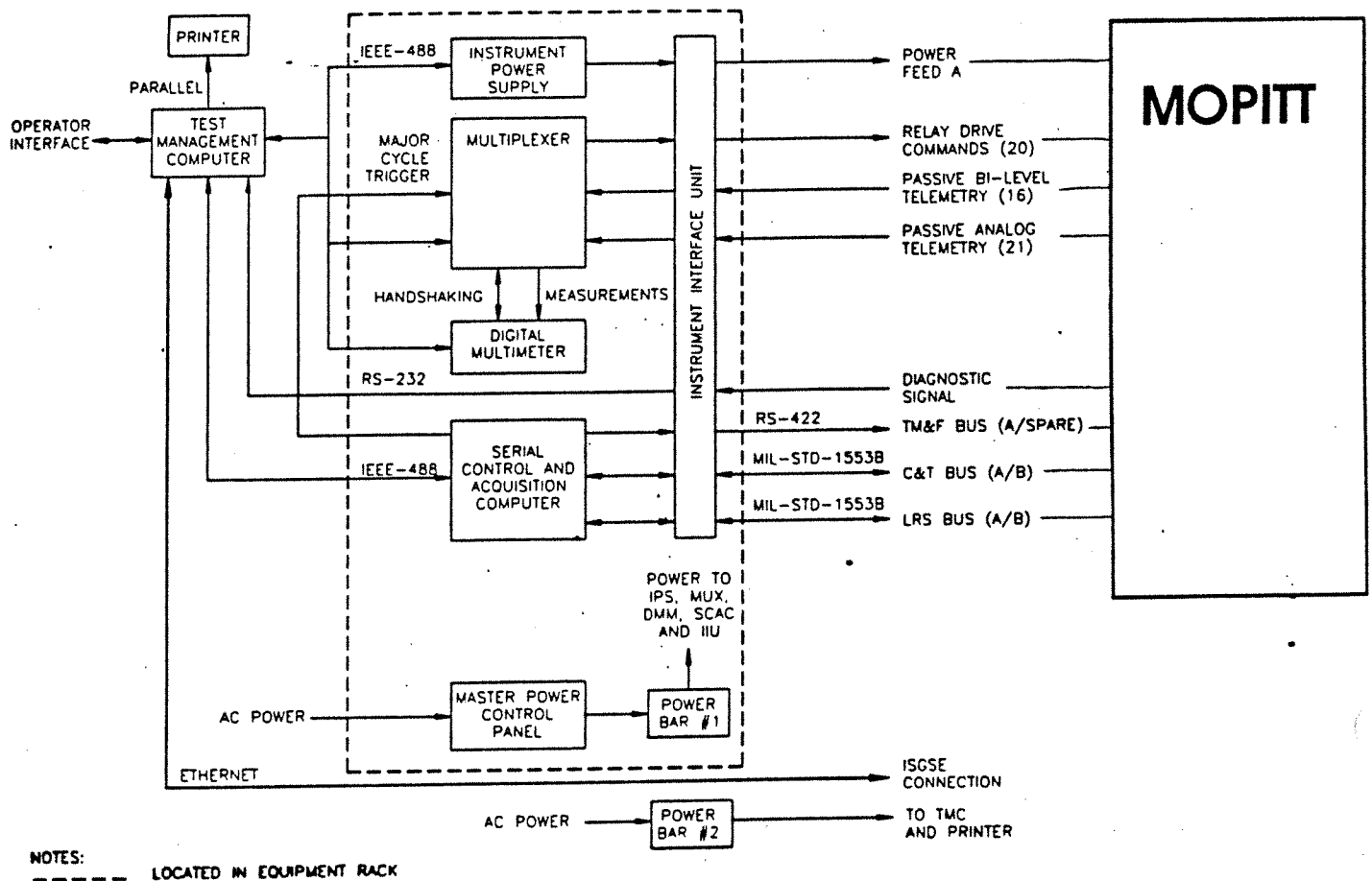


Figure 3.1.1-2: Functional Diagram of MOPITT Instrument in Stand Alone Configuration

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3.1.1

MOPITT Instrument Diagrams and Functional Description

This section defines the MOPITT Instrument functionality and configuration.

The MOPITT Instrument top level functional requirements are summarized below;

- optical imaging
- cross-track scanning
- high speed chopping of optical beam
- optical spectral modulation
- optical spectral filtering
- in flight calibration
- synchronous demodulation and signal processing
- command and telemetry
- internal power conversion and conditioning
- automated aperture cover opening
- temperature monitoring
- heater control
- active cryogenic cooling for temperature critical components
- automated instrument control based on operational parameters

Figure 3.1.1-3 is functional block diagram of the MOPITT Instrument which shows the functional elements as single blocks.

The instrument functions by analyzing incoming IR radiation and producing signals that relate to radiation intensity distributions in wavelength. The instrument sends this science data, engineering data, housekeeping data, and ancillary data through an external electrical interface. The electrical interface also provides the instrument with power (from a 120 Vdc supply), timing data and commands. The instrument will mount on a set of three kinematic mounts. An external cooling loop and a radiator plate will remove heat from the MOPITT Instrument.

A more detailed functional diagram of a single channel within the MOPITT Instrument is shown in Figure 3.1.1-4, and is described in the following paragraphs.

A scan mirror directs IR radiation from either an external target or an internal calibration source to the fore optics. The beam is imaged onto a chopper where a small aperture is chopped at a high rate. The mid optics relays the beam through the gas modulating cell which operates at a lower frequency. The rear optics includes an optical bandpass filter, and images the beam onto an IR detector. The detector, optical filter and condensing optics are cryogenically cooled to minimize noise.

The detector output is amplified, filtered, and then digitized. The position of the chopper and the gas modulating cells are electronically fed to the signal processing electronics where synchronous

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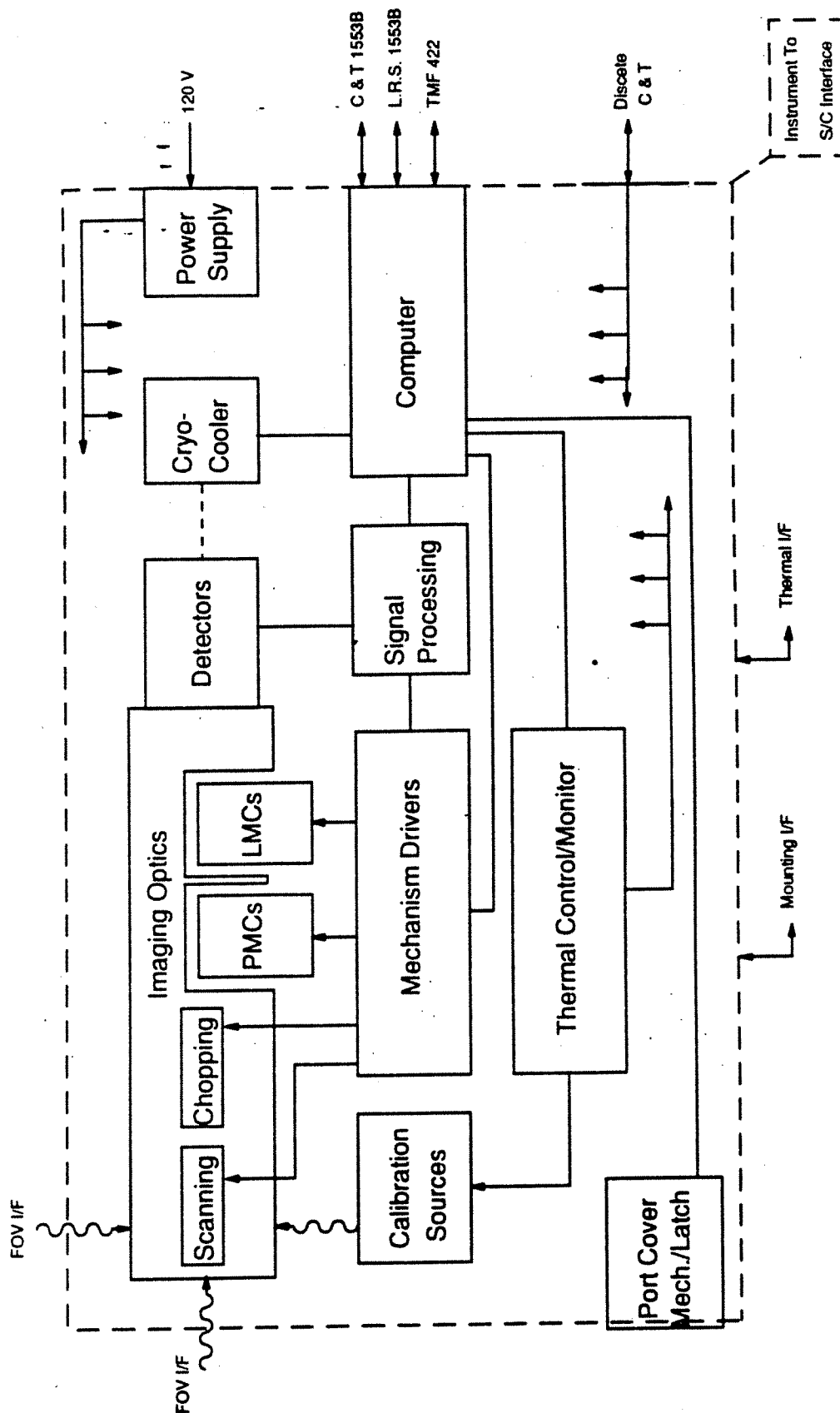


Figure 3.1.1-3: MOPITT Instrument Functional Diagram

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detection techniques are used to extract the science data products (these are defined in section 3.1.1.2 of this document).

The signals are collated in the MOPITT Instrument Controller Module (ICM), and formatted into packets and transferred to the spacecraft data bus. The spacecraft telemetry system sends the data to the ground station where the data is linked to the EOS Data Information System (EOSDIS) science terminal for processing.

Onboard calibration sources and a deep space view are used to provide an absolute IR radiation reference for the MOPITT instrument over its five year operating life.

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3.1.1.1 Detailed Functional Requirements

This section describes requirements that are primarily functional in nature. Section 3.2.1 describes the instrument requirements that are primarily performance in nature.

3.1.1.1.1 Optical Channel Configuration

MOPITT requires eight optical channels, each with dedicated detectors and bandpass filters. The scanning and fore optics should be shared between two channels. In some cases the gas correlation filter is also shared between two channels. The details of the channels and their characteristics are provided in Table 3.1.1.1-1. The portions of the instrument that are shared between channels are shown in Figure 3.1.1.1-1.

Channel 4 is fully redundant with Channel 8.

Channel 2 is a backup to channel 6, however channel 6 shall be the primary channel.

Channels 1, 3, 5 and 7 combine to provide the vertical resolution for the carbon monoxide gas. All four of these channels are used during normal operations.

Table 3.1.1.1-1 : MOPITT Channel Characteristic Summary

Channel Characteristic	1	2	3	4	5	6	7	8
Gas Species	CO	CO	CO	CH ₄	CO	CO	CO	CH ₄
Nominal Gas Pressure [kPa]	20	20	7.5	80	80	80	3.8	80
Minimum Gas Pressure [kPa]	20 (TBC)	20 (TBC)	5 (TBC)	N/A	80 (TBC)	80 (TBC)	3.8 (TBC)	N/A
Maximum Gas Pressure [kPa]	TBD	TBD	TBD	N/A	TBD	TBD	TBD	N/A
Mid-Wavenumber [cm ⁻¹]	2166	4285	2166	4430	2166	4285	2166	4430
Wavenumber Range [cm ⁻¹]	52	40	52	139	52	40	52	139
Mid-Wavelength [μm]	4.617	2.334	4.617	2.258	4.617	2.334	4.617	2.258
Wavelength Range [μm]	0.111	0.022	0.111	0.071	0.111	0.022	0.111	0.071
Modulator Type & Number	LMC 1	LMC 1	PMC 1	LMC 2	LMC 3	LMC 3	PMC 2	LMC 4
*Nominal Modulator Frequency [Hz]	10.61	10.61	48.12	13.12	10.61	10.61	40.49	11.04
** Nominal Chopper Frequency [Hz]	509.2	509.2	577.4	577.4	509.2	509.2	485.9	485.9
Scan Mirror/Chopper Number	1	1	2	2	3	3	4	4
Optical Table	1	1	1	1	2	2	2	2
Sieve	1	1	2	N/A	3	3	4	N/A

* LMC units are rotations per second

** Exact frequencies are dependant on the as built PMC natural frequency

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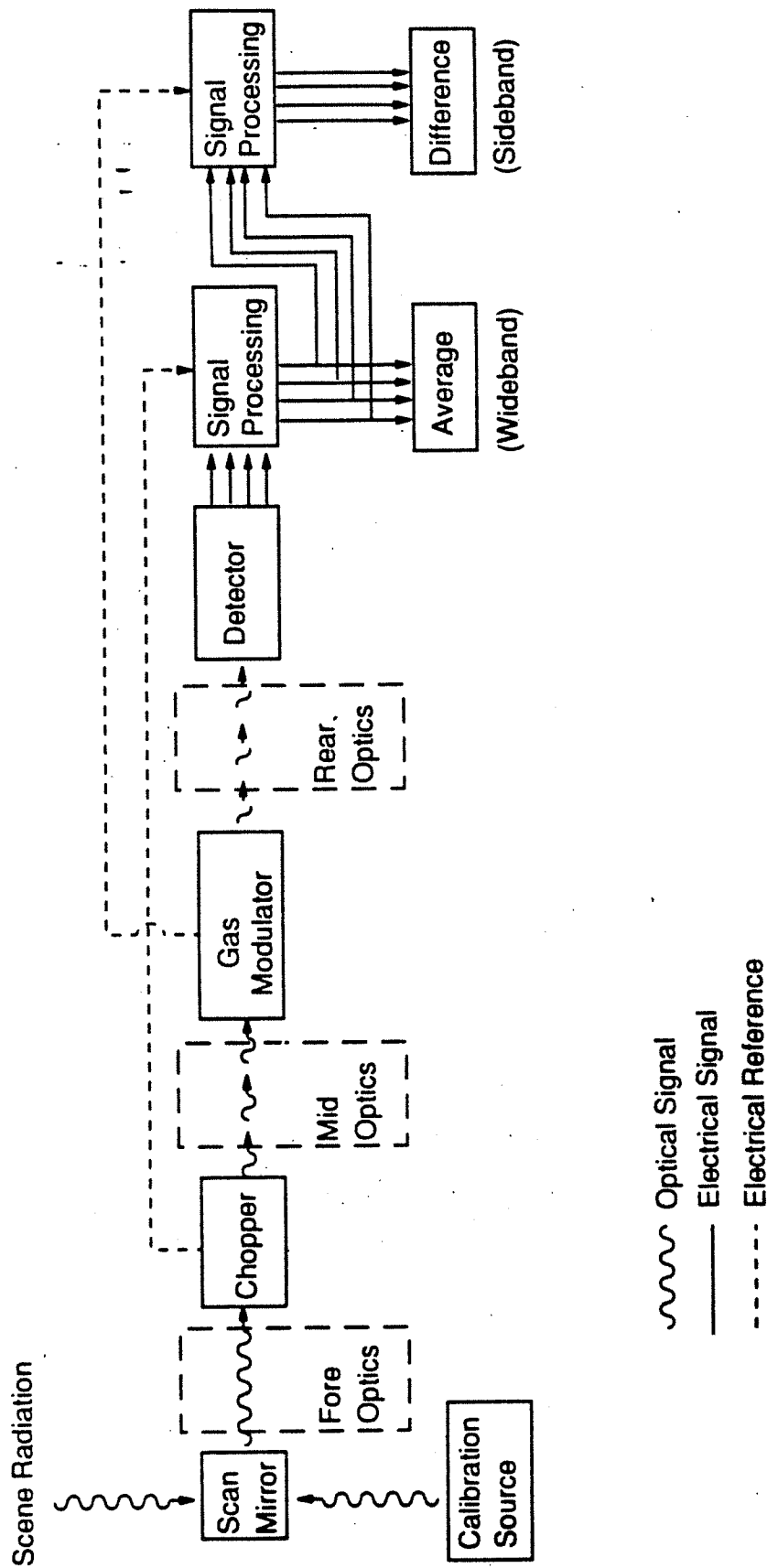


Figure 3.1.1-4: MOPITT Instrument Single Channel Functional Diagram

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3.1.1.1.2 Signal and Data Processing

The signal processing electronics shall take the output of the detector array (which includes a pre-amplifier) and timing reference signals, and for each pixel extract the required data products.

The data products generated will be used to derive the "difference-band" and the "average-band" signals by the Science Ground Processing Software.

The data products are defined for three types of data channels in the MOPITT instrument;

-LMC solar (Channel #2, Channel #4, Channel #6 and Channel #8)

-LMC thermal (Channel #1 and Channel #5)

-PMC thermal (Channel #3 and Channel #7)

The following tables define the basic data products that will be telemetered every scan stare period for each pixel. The exact format will depend on the algorithm used onboard for data reduction. These tables show the baseline algorithm. Each data packet, which is sent once per scan mirror stare, could start at any LMC sector or either PMC stroke since there are no constraints placed on the timing between the scan mirror and the LMC or PMC. The LMC sectors are labelled as A, B, C and D. The PMC sectors are labelled as L (low pressure) or H (high pressure). The sums are defined for the chopper open and chopper closed cases.

The sums listed in Tables 3.1.1.1-1, 3.1.1.1-2 and 3.1.1.1-3 are scaled onboard by a programmable factor.

Each data packet header shall include the initial sector and the programmable factor used.

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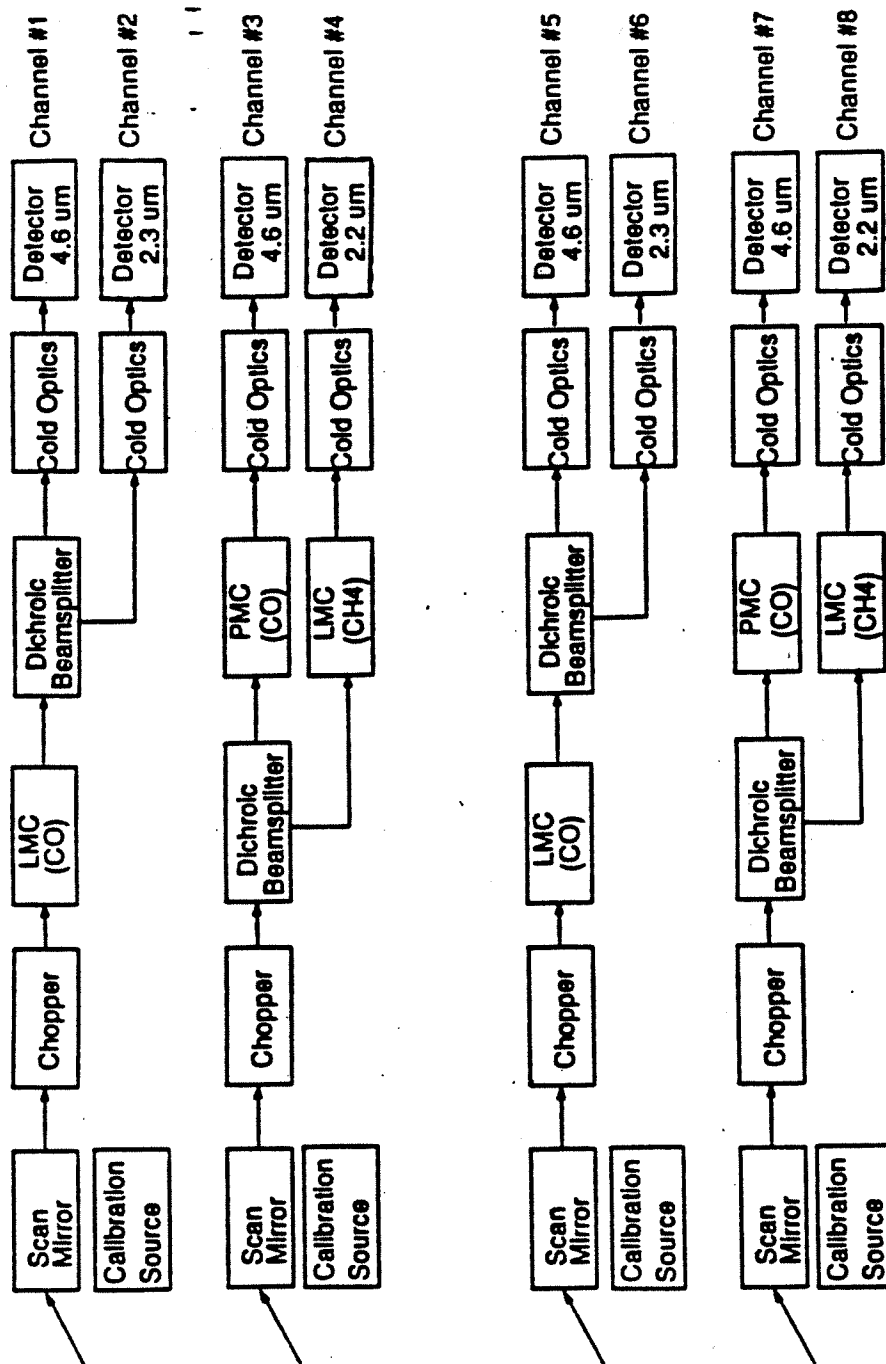


Figure 3.1.1.1-1: MOPITT Instrument Channel Configuration

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LMC Rotation #	Data Size [Bits]	Chopper Status	Sector	Data Designator	Data Description
1,2,3,4	24	closed	A	$\sum_{i=1}^4 A_{i \text{ closed}}$	Sector A Sums, Summed over 4 Rotations
1,2,3,4	24	closed	B	$\sum_{i=1}^4 B_{i \text{ closed}}$	Sector B Sums, Summed over 4 Rotations
1,2,3,4	24	closed	C	$\sum_{i=1}^4 C_{i \text{ closed}}$	Sector C Sums, Summed over 4 Rotations
1,2,3,4	24	closed	D	$\sum_{i=1}^4 D_{i \text{ closed}}$	Sector D Sums, Summed over 4 Rotations

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Table 3.1.1.1-1 : Data Product Format For LMC Solar Channels (#2, #4, #6, #8)

LMC Rotation #	Data Size [Bits]	Chopper Status	Sector	Data Designator	Data Description
1	24	open	A	$A_{1 \text{ open}}$	Rotation 1, Sector A Sum
2	16	open	A	$\Delta A_{2 \text{ open}}$	Rotation 2, Sector A Sum - Rotation 1, Sector A Sum
3	16	open	A	$\Delta A_{3 \text{ open}}$	Rotation 3, Sector A Sum - Rotation 1, Sector A Sum
4	16	open	A	$\Delta A_{4 \text{ open}}$	Rotation 4, Sector A Sum - Rotation 1, Sector A Sum
1	24	open	B	$B_{1 \text{ open}}$	Rotation 1, Sector B Sum
2	16	open	B	$\Delta B_{2 \text{ open}}$	Rotation 2, Sector B Sum - Rotation 1, Sector B Sum
3	16	open	B	$\Delta B_{3 \text{ open}}$	Rotation 3, Sector B Sum - Rotation 1, Sector B Sum
4	16	open	B	$\Delta B_{4 \text{ open}}$	Rotation 4, Sector B Sum - Rotation 1, Sector B Sum
1	24	open	C	$C_{1 \text{ open}}$	Rotation 1, Sector C Sum
2	16	open	C	$\Delta C_{2 \text{ open}}$	Rotation 2, Sector C Sum - Rotation 1, Sector C Sum
3	16	open	C	$\Delta C_{3 \text{ open}}$	Rotation 3, Sector C Sum - Rotation 1, Sector C Sum
4	16	open	C	$\Delta C_{4 \text{ open}}$	Rotation 4, Sector C Sum - Rotation 1, Sector C Sum
1	24	open	D	$D_{1 \text{ open}}$	Rotation 1, Sector D Sum
2	16	open	D	$\Delta D_{2 \text{ open}}$	Rotation 2, Sector D Sum - Rotation 1, Sector D Sum
3	16	open	D	$\Delta D_{3 \text{ open}}$	Rotation 3, Sector D Sum - Rotation 1, Sector D Sum
4	16	open	D	$\Delta D_{4 \text{ open}}$	Rotation 4, Sector D Sum - Rotation 1, Sector D Sum

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Table 3.1.1.1-3 : Data Product Format For PMC Thermal Channels (#3, #7)

PMC Cycle #	Data Size [Bits]	Chopper Status	Stroke	Data Designator	Data Description
1,2,3...N N ₃ ~ 20 N ₇ ~ 16	24	open	Low (Pressure)	$\sum_{i=1}^N L_{i \text{ open}}$	Low Stroke Sums, Summed over N Cycles
1,2,3...N N ₃ ~ 20 N ₇ ~ 16	24	open	High (Pressure)	$\sum_{i=1}^N H_{i \text{ open}}$	High Stroke Sums, Summed over N Cycles
1,2,3...N N ₃ ~ 20 N ₇ ~ 16	24	closed	Low (Pressure)	$\sum_{i=1}^N L_{i \text{ closed}}$	Low Stroke Sums, Summed over N Cycles
1,2,3...N N ₃ ~ 20 N ₇ ~ 16	24	closed	High (Pressure)	$\sum_{i=1}^N H_{i \text{ closed}}$	High Stroke Sums, Summed over N Cycles

N₃ and N₇ are number of PMC cycles per stare for channels 3 and 7 respectively.

3.1.1.1.3 Instrument Control and Timing

The instrument controller forms the heart of the instrument electronics and controls of all other electronics within the instrument.

The instrument shall have a central timing circuit that ensures that the chopper mechanism is synchronized with the PMC and LMC. The instrument timing and control shall be cold redundant.

The instrument controller will also provide an external test port and supporting functionality to allow instrument control, diagnosis, health and status monitoring during ground testing.

3.1.1.1.4 Telemetry Interface

The telemetry interface shall be configured as discrete command/telemetry lines through the Bus Data Unit (BDU), hot redundant 1553B Command & Telemetry bus, hot redundant 1553B Low Rate Science bus and hot redundant RS422 Time Mark and Frequency bus.

The telemetry interface shall act as a MIL-STD-1553 Remote Terminal (RT) on both the dual redundant Command and Telemetry interface bus and the dual redundant Low Rate Science interface bus. The RT functionality conforms to the limitations and exceptions listed in AD1.

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Table 3.1.1.1-2 : Data Product Format For LMC Thermal Channels (#1, #5)

LMC Rotation #	Data Size [Bits]	Chopper Status	Sector	Data Designator	Data Description
1,2,3,4	24	open	A	$\sum_{i=1}^4 A_{i \text{ open}}$	Sector A Sums, Summed over 4 Rotations
1,2,3,4	24	open	B	$\sum_{i=1}^4 B_{i \text{ open}}$	Sector B Sums, Summed over 4 Rotations
1,2,3,4	24	open	C	$\sum_{i=1}^4 C_{i \text{ open}}$	Sector C Sums, Summed over 4 Rotations
1,2,3,4	24	open	D	$\sum_{i=1}^4 D_{i \text{ open}}$	Sector D Sums, Summed over 4 Rotations
1,2,3,4	24	closed	A	$\sum_{i=1}^4 A_{i \text{ closed}}$	Sector A Sums, Summed over 4 Rotations
1,2,3,4	24	closed	B	$\sum_{i=1}^4 B_{i \text{ closed}}$	Sector B Sums, Summed over 4 Rotations
1,2,3,4	24	closed	C	$\sum_{i=1}^4 C_{i \text{ closed}}$	Sector C Sums, Summed over 4 Rotations
1,2,3,4	24	closed	D	$\sum_{i=1}^4 D_{i \text{ closed}}$	Sector D Sums, Summed over 4 Rotations

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Table 3.1.1.1-4 : Temperature Monitoring Requirements

Component	Monitored By	Use	Type	Qty	Min. Temp. [K]	Max Temp. [K]	Res. [K]	Accy [°K]	Critical Rqmt.	Sensor Assy [°K]	Circuit Assy [°K]	Telemetry Assymtn	Sampling Interval [s]
Baffle (Nadir View)	BDU	Surv	Therm	1	240	370	1	2		0.5	1.936	TR_BDU_BAFFLE_EA	
Baffle (Space View)	BDU	Surv	Therm	1	240	370	1	2		0.5	1.936	TR_BDU_BAFFLE_SP	
Base Plate	BDU	Surv	Therm	1	250	370	1	2		0.5	1.936	TR_BDU_SPLT_MAX	
Base Plate	BDU	Surv	Therm	1	250	370	1	2		0.5	1.936	TR_BDU_SPLT_MIN	
Bus VF Card (C&T)	BDU	Trbl. Shoot	Therm	1	270	370	1	2		0.5	1.936	TR_BDU_CT_F	
Bus VF Card (LRS)	BDU	Trbl. Shoot	Therm	1	270	370	1	2		0.5	1.936	TR_BDU_LRS_F	
Port Cover Motor/Hinge (Nadir)	BDU	Surv	Therm	1	240	370	1	2		0.5	1.936	TR_BDU_PCA_EARTH	
Port Cover Motor/Hinge (Space)	BDU	Surv	Therm	1	240	370	1	2		0.5	1.936	TR_BDU_PCA_SPACE	
PSM	BDU	Surv	Therm	2	240	370	1	2		0.5	1.936	TR_BDU_PSM_A-B	
Spare (TBC)	BDU	Surv	Therm	11	250	370	1	2		0.5	1.936	TR_BDU_SPARE_A	
BDU Total				21									
Cold Tips 1&2	CDE	Contr	Diode	2	70	350	0.1	1		0.5	0.866	TR_COOL_TIP	8.192
Displacer 1&2	CDE	Help	Diode	2	250	350	0.1	1		0.5	0.866	TR_COOL_DISP	8.192
CDE	CDE	Help	Diode	3	250	350	0.1	1		0.5	0.866	TR_COOL_CDE	8.192
CDE Total				7									
Cal Source 1-4	TCMM A	Sci	PRT	8	270	510	0.005	0.1	A/R	0.05	0.087	TR_ENG_CAL_A	0.45
Cal Source 1-4	TCMM B	Sci	PRT	8	270	510	0.005	0.1	A/R	0.05	0.087	TR_ENG_CAL_B	0.45
Mol. Sieves	TCMM A	Sci	PRT	4	270	400	0.02	1		0.5	0.866	TR_ENG_BEVE_A	0.45
Mol. Sieves	TCMM B	Sci	PRT	4	270	400	0.02	1		0.5	0.866	TR_ENG_BEVE_B	0.45
Cold Filters	TCMM A/B (X-strap)	Sci	Diode	4	70	350	0.1	1	C	0.5	0.866	TR_ENG_FILTER_A	0.45
Detectors 1-8	TCMM A/B (X-strap)	Sci	Diode	8	70	350	0.1	1	C	0.5	0.866	TR_ENG_DETECTORS	0.45
Compressor 1&2	TCMM A/B (X-strap)	Help	Therm	2	250	370	0.1	1		0.5	0.866	TR_COOL_COMP	8.192
PMC Motors	TCMM A/B (X-strap)	Help	Therm	2	250	370	0.1	1		0.5	0.866	TR_PMC_MTR	8.192
LMC Motors	TCMM A/B (X-strap)	Help	Therm	4	250	370	0.1	1		0.5	0.866	TR_LMC_MTR	8.192
Scan Motors	TCMM A/B (X-strap)	Help	Therm	4	250	370	0.1	1		0.5	0.866	TR_SCAN_MTR	8.192
Chopper Motors	TCMM A/B (X-strap)	Help	Therm	4	250	370	0.1	1		0.5	0.866	TR_CHOP_MTR	8.192
Pressure Sensors	TCMM A/B (X-strap)	Sci	Therm	4	250	350	0.006	1	R/C	0.05	0.999	TR_ENG_PRES	
LMC Gas	TCMM A/B (X-strap)	Sci	Therm	4	250	350	0.006	1	R/C	0.05	0.999	TR_ENG_LMC_A	0.45
PMC Gas	TCMM A/B (X-strap)	Sci	Therm	2	250	350	0.006	1	R/C	0.05	0.999	TR_ENG_PMC_A	0.45
Base Plate	TCMM A/B (X-strap)	Help/Sci	Therm	3	250	370	0.1	1		0.5	0.866	TR_BDU_PCA_A	8.192
Choppers 1-4	TCMM A/B (X-strap)	Sci	Therm	4	250	350	0.006	1	R/C	0.5	0.866	TR_ENG_CHOP_A	0.45
Optical Chassis 1/2	TCMM A/B (X-strap)	Sci	Therm	8	250	350	0.1	1		0.5	0.866	TR_ENG_OPT_A	
PSM	TCMM A/B (X-strap)	Help/Sci	Therm	1	240	370	0.1	2		0.5	1.936	TR_PSM	8.192
Scan Mirrors 1-4	TCMM A/B (X-strap)	Sci	Therm	4	240	370	0.1	1		0.5	0.866	TR_ENG_SCAN	0.45
SPM 1&2	TCMM A/B (X-strap)	Help/Sci	Therm	2	270	370	0.1	2		0.5	1.936	TR_SPM	0.45
TCMM Internal Monitors	TCMM A	Help	Therm	2	250	350	0.1	2		0.5	1.936	TR_TCMM_A	8.192
TCMM Internal Monitors	TCMM B	Help	Therm	2	250	350	0.1	2		0.5	1.936	TR_TCMM_B	8.192
Spare (TBC)	TCMM A/B (X-strap)	Help/Sci	Therm	3	250	370	0.1	1		0.5	0.866	TR_SPARE_A	
TCMM Total				91									
Port Cover Latch (Nadir)	PCDM A	Help	Therm	1	220	370	0.1	2		0.5	1.936	TR_LATCH_EARTH	8.192
Port Cover Latch (Space)	PCDM A	Help	Therm	1	220	370	0.1	2		0.5	1.936	TR_LATCH_SPACE	8.192
Port Cover Latch (Nadir)	PCDM B	Help	Therm	1	220	370	0.1	2		0.5	1.936	TR_LATCH_EARTH	8.192
Port Cover Latch (Space)	PCDM B	Help	Therm	1	220	370	0.1	2		0.5	1.936	TR_LATCH_SPACE	8.192
Port Cover Motor/Hinge (Nadir)	PCDM A	Help	Therm	2	220	370	0.1	2		0.5	1.936	TR_PCA_EARTH_A	8.192
Port Cover Motor/Hinge (Space)	PCDM A	Help	Therm	2	220	370	0.1	2		0.5	1.936	TR_PCA_SPACE_A	8.192
Port Cover Motor/Hinge (Nadir)	PCDM B	Help	Therm	2	220	370	0.1	2		0.5	1.936	TR_PCA_EARTH_B	8.192
Port Cover Motor/Hinge (Space)	PCDM B	Help	Therm	2	220	370	0.1	2		0.5	1.936	TR_PCA_SPACE_B	8.192
PCDM Total				12									
Total				131									
(Total Used at One Time)				97									
1)	BDU (Bus Data Unit spacecraft interface) sensors are used for survival status and although these may be available as housekeeping data in all instrument modes, they should not be baselined for necessary operational temperature data.												
2)	TCMM (Thermal Control and Monitoring Module) sensors are primarily engineering data (used for science data interpretation) but can also be used for health status. The exception is that points which are temperature controlled by the TCMM are also monitored by the TCMM.												
3)	PCDM (Port Cover Drive Module) sensors are primarily housekeeping data, but may be used for engineering data (used for science data interpretation) if required.												
4)	Survival means that the instrument is in survival mode and that heaters are maintaining the equipment at acceptable power-up temperatures based on separate temperature monitors (thermostats), not included in this list. The range values are all TBC.												
*	The resolution and accuracy requirements apply to the middle of the temperature range. The only exceptions are the calibration sources, cold filters and detectors which require the greatest resolution in the lowest quartile.												
**	The temperature monitoring requirement is driven by either accuracy (A), resolution (R), or constancy (C).												
---	The circuit accuracy for Calibration Sources may fall off to 0.5 K at 350 K (TBC).												
----	High and low temperature points.												
-----	PRT data will be either coarse or fine.												

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3.1.1.1.5 Instrument Computer

The instrument computer shall provide control to all functions of the instrument, respond to ground commands and format housekeeping and scientific data for transmission. The utilization of the computer resources in the design shall not exceed the following guidelines for PDR, CDR and post-CDR:-

	<u>PDR</u>	<u>CDR</u>	<u>Post-CDR</u>
a) Non-volatile memory (ROM or PROM)	65%	85%	90%
b) Volatile memory (RAM)	40%	50%	60%

3.1.1.1.6 Thermal Control and Monitoring

The instrument is required to provide monitoring and control for critical temperatures, science processing temperatures and housekeeping temperatures. During survival mode the critical temperature monitoring is provided through the BDU and also through autonomous self-contained instrument survival temperature control circuits.

The temperature control circuits are generally of two types; on/off or programmable. The heaters within the instrument are used for maintaining survival temperature limits, maintaining operating temperature limits, driving off contaminants, or setting performance temperatures.

The science requirements for temperature monitoring are described in AD4 section 7.2.4.3. All temperature monitoring requirements are shown in Table 3.1.1.1-4. Active thermal control requirements are shown in Table 3.1.1.1-5.

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3.1.1.1.7 Voltage Conversion and Isolation

The 120 Vdc supply power must be converted to the required voltages and currents for the instrument circuitry (as defined in section 3.7.3.2.4). Specific rails are isolated to allow for low noise operation of critical circuits. This shall be implemented in a power supply module containing two power-supply units that shall be cold redundant in a noncross-strapped manner. The power supply module shall be thermally isolated from the instrument (except for small parasitic coupling) and shall dissipate its own heat through radiative cooling.

The grounding of rails shall be implemented in a manner providing low noise emissions and sensitivity, following the MOPITT EMC control plan (RD8).

3.1.1.1.8 Internal Signal Routing

The various electrical signals within the instrument must be routed between the various modules. The routing shall be implemented in a high reliability fashion while controlling noise to an acceptable level, following the MOPITT EMC control plan (RD13). To minimize harness complexity N to N wiring harnesses should be avoided.

3.1.1.1.9 Structural Support

All instrument hardware modules will mount to the instrument baseplate or walls. The structure is required to support these modules during ground tests, shipping, launch and on-orbit operation. The structure shall provide the required structural stability for each module. The structure shall also provide the 3 point mounting interface to the spacecraft as described in AD1 and AD2. The structure shall provide necessary attachment points to the handling and shipping fixtures.

3.1.1.1.10 Contamination Sealing

The MOPITT Instrument interior shall be protected from molecular contamination and particulate contamination during ground tests, shipping, storage and launch. The seal integrity shall be such that the instrument can be purged with acceptable flow rates.

The port covers will be opened during ground tests and on orbit and where they will remain open. The ports can be closed manually following ground tests.

Prior to launch (and vacuum tests) the purge must be released. Launch depressurization vents must be installed at this time (or covers removed from existing vents). The vent path should be such that the optical surfaces are not in the direct path. The optical surfaces that are sensitive to contamination are all mirrors, lenses, windows, beamsplitters, and the calibration sources. There are external vent path requirements defined in AD1, AD3 and RD7.

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Table 3.1.1.1-5 : Thermal Control Requirements

Component	Controlled By	Use	Type	Qty	Min. Temp. [K]	Max Temp. [K]	Power [W]	Comments	Device #
Detector Nest (Table 1) A	TCMM A	Hskp/Contam	2	1	70	350	4 (TBC)		0
Detector Nest (Table 1) B	TCMM B	Hskp/Contam	2	1	70	350	4 (TBC)		0
Detector Nest (Table 2) A	TCMM A	Hskp/Contam	2	1	70	350	4 (TBC)		1
Detector Nest (Table 2) B	TCMM B	Hskp/Contam	2	1	70	350	4 (TBC)		1
Calibration Sources A	TCMM A	Sol	2	4	270	510	15		6-9
Calibration Source B	TCMM B	Sol	2	4	270	510	15		6-9
Sieve (LMC 1)	TCMM A/B with X-strap	Sol	4	1	270	375	4		10
Sieve (LMC 3)	TCMM A/B with X-strap	Sol	4	1	270	375	4		11
Sieve (PMC 1)	TCMM A/B with X-strap	Sol	4	1	270	375	4		12
Sieve (PMC 2)	TCMM A/B with X-strap	Sol	4	1	270	375	4		13
TCMM Total				16					
Earth Port Cover Motor/Hinge A	PCDM A	Safety	3	1	250	350	2 (TBC)		2
Earth Port Cover Motor/Hinge B	PCDM B	Safety	3	1	250	350	2 (TBC)		2
Earth Port Cover Latch A	PCDM A	Safety	3	1	250	350	2 (TBC)		4
Earth Port Cover Latch B	PCDM B	Safety	3	1	250	350	2 (TBC)		4
Space Port Cover Motor/Hinge A	PCDM A	Safety	3	1	250	350	2 (TBC)		3
Space Port Cover Motor/Hinge B	PCDM B	Safety	3	1	250	350	2 (TBC)		3
Space Port Cover Latch A	PCDM A	Safety	3	1	250	350	2 (TBC)		5
Space Port Cover Latch B	PCDM B	Safety	3	1	250	350	2 (TBC)		5
PCDM Total				8					
PSM A	SSU A Thermostat	Survival	1	1	220	370	25 (TBC)		N/A
PSM B	SSU B Thermostat	Survival	1	1	220	370	25 (TBC)		N/A
Earth Port Cover Motor/Hinge A	SSU A Thermostat	Survival	1	1	250	350	2 (TBC)		N/A
Earth Port Cover Motor/Hinge B	SSU B Thermostat	Survival	1	1	250	350	2 (TBC)		N/A
Space Port Cover Motor/Hinge A	SSU A Thermostat	Survival	1	1	250	350	2 (TBC)		N/A
Space Port Cover Motor/Hinge B	SSU B Thermostat	Survival	1	1	250	350	2 (TBC)		N/A
Space Port Cover Latch A	SSU A Thermostat	Survival	1	1	250	350	2 (TBC)		N/A
Earth Port Cover Latch A	SSU A Thermostat	Survival	1	1	250	350	2 (TBC)		N/A
SSU Thermostat Total				8					
Heater Control Types	-1 an on/off control based on non-programmable temperature limits (Survival Supply Unit -SSU)								
	-2 a 256 state programmable open loop control circuit								
	-3 an on/off control based on programmable temperature limits								
	-4 a 256 state programmable open loop control circuit, with an additional 256 state fine tuning control which could be enabled.								

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3.1.1.2 MOPITT Configuration Description

This section describes how the MOPITT Instrument is configured to achieve the functional requirements described in the previous section.

The MOPITT Instrument configuration is based around accommodating the eight channels described in Table 3.1.1.1-1 in section 3.1.1.1.

The instrument is divided into the following nine major components;

- the optical subsystem
- the PMC assemblies
- the LMC assemblies
- the electronics modules
- the calibration sources
- the structural/thermal subsystem (instrument structure)
- the cooler subsystem (two coolers and drive module)
- the detection arrays
- the instrument software

The following table shows the mapping of the instrument's function requirements to the major components.

The instrument functional configuration is shown in Figure 3.1.1.2-1. The Table 3.1.1.2-2 shows the hardware configuration of the major components. Lower level specification numbers as shown in the table (other documents such as ICDs and manufacturing drawings are not listed).

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3.1.1.1.11 Cryogenic Cooling

The detector packages must be cooled to less than 100 K, and the filter, condensing optics and aperture stop must be cooled to less than 140 K. The cooling shall be enabled by software command.

3.1.1.1.12 Heat Path to Cooling Loop

The heat dissipated by the various modules (except for the PSM) must be conducted to the external cooling loop (coldplate) which is attached to the bottom side of the instrument baseplate. The thermal performance shall be calculated using worse case assumptions about radiative heat transfer between modules and the structure or other modules. The design guideline is to maximize the optical enclosure temperature stability, and to maintain acceptable temperatures throughout the instrument. The interface between the coldplate and the instrument shall meet the requirements in AD1.

3.1.1.1.13 Thermal and Radiation Shielding

The direct sunlight, reflected sunlight, and Earth IR will cause thermal loading on the instrument. The instrument must be protected from these sources to maintain acceptable temperatures and acceptable temperature drift rates. Where possible, MLI should be used on exterior surfaces. The port cover underside and the aperture ports will not be compatible with MLI usage. The aperture port baffles shall have a low reflectance coating (< 0.3 TBC) and a low BSDF (Harvey-Shack Model slope $> TBD$, intercept $< TBD$).

3.1.1.1.14 Power Distribution and Fusing

The instrument should contain a central fusing module that has reasonable access to repair damaged fuses during ground tests. A fuse shall be utilized to isolate any single point failure.

3.1.1.1.15 Voltage and Current Monitoring

The instrument shall monitor currents to motors and voltages across heaters. This data shall be telemetered as per 3.7.9 of this document.

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Table 3.1.1.2-2: MOPITT Instrument Hardware Summary

MOPITT Instrument Hardware Summary

Hardware Item	Specification	Comments
Optical Subsystem	EQS/MOP/113361/100	
- optical table		
- table structure		
- scan mirror assemblies (4) each containing		
- scan mirror		
- scan motor/encoder assembly	EQS/MOP/113361/101	
- chopper assemblies (4) each containing		
- chopper motor	EQS/MOP/113361/102	
- encoder		
- bracket		
- shroud		
- vane		
- LMC return mirrors (4)		
- optical chassis (2) each containing		
- optical chassis plate & mounts		
- lenses, mirrors, beamsplitters and mounts		
- dewar assembly		
- dewar		
- detector cold optics (4)	EQS/MOP/113365/500	
- cold optics		included in optical s/s spec.
- detector	EQS/MOP/113365/500	

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Table 3.1.1.2-1 : Major Components Functional Description

Major Component Name	Functions
Optical Subsystem	Scanning Chopping Optical Relaying/Imaging Optical Frequency Filtering Stray Light Baffling (partial) Optical Channels (partial)
PMC Assemblies	Gas Correlation Filtering (partial)
LMC Assemblies	Gas Correlation Filtering (partial)
Electronics Modules	Voltage Conversion/Isolation Telemetry Interface Signal Processing and Digitizing Instrument Timing and Control Thermal Monitoring and Control Mechanism Drive Voltage, Current Monitoring Power Distribution and Fusing
Calibration Sources	Radiance Calibration
Structural/Thermal Subsystem	Structural Support Contamination Sealing Cryogenic Cooling Heat Path to Cooling Loop Thermal Radiation Shielding Stray Light Baffling (partial) Internal Signal Routing
Cooler Subsystem	Cryogenic Cooling and Drive
Detection Arrays	IR Detection Optical Channels (partial)
Instrument Software	ICM Control

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Hardware Item	Specification	Comments
Cooler Subsystem		
- compressor/displacer with tubing (2)	EQS/MOP/113362/201	
- mounting bracket	CD 100051-01-360	
- cooler drive electronics	CD 100051-01-360	includes test harness
- cooler harness		
Instrument Structure		
- baseplate and alignment cube		
- cover		
- port cover assemblies (2) each containing		
- actuator	EQS/MOP/113366/603	
- wall		
- baffles (4)		
- latch	EQS/MOP/113366/603	
- harness		

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Hardware Item	Specification	Comments
Instrument Electronic Modules		
- TCMM	EQS/MOP/113363/306	
- PSM	EQS/MOP/113363/301	
- PDM	EQS/MOP/113363/311	
- SPM (2)	EQS/MOP/113363/304	
- SCDM	EQS/MOP/113363/309	
- PLDM	EQS/MOP/113363/310	
- PCDM	EQS/MOP/113363/305	
- ICM	EQS/MOP/113363/303	
Calibration Sources (4)	EQS/MOP/113367/701	
LMC Assemblies (2) each containing	EQS/MOP/113361/105	
- LMC (2)		
- bracket		
- sieve (1)		U. of T. / CSA
- pressure sensor (2)	SC100551-02-224	SC 100551-01-224 for EQM
- tubing (2)		
PMC Assemblies (2) each containing		
- PMC (1)		U. of T. / CSA
- bracket (1)		
- sieve (1)		U. of T. / CSA
- tubing (1)		

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3.1.2 Interface Definition

This section delineates the instrument external interfaces with the EOS environment and spacecraft, internal interfaces between major components of the instrument, and instrument diagnostic interfaces.

The instrument external interfaces are fully defined in RD1 and its sub-document set.

The internal interfaces defined in section 3.1.2.2 are optical and electrical only (except for the cooler subsystem cryogenic thermal interface).

3.1.2.1 External Interfaces

The Instrument shall provide the external interfaces listed below. These comprise the instrument direct interfaces with the EOS external environment and spacecraft. Specifications for the interfaces are defined by AD1. The relationship between the interfaces and the major components of the Instrument are shown in Figure 3.1.2.1-1. The following paragraphs identify the intended application of these interfaces. The electrical connectors are defined in RD3 and RD1 and shall comply with sections 3.14.5.1, 3.14.5.2, 3.14.5.10.1, 3.14.5.10.2, 3.14.5.10.3 of AD1 unless exceptions are identified in RD11.

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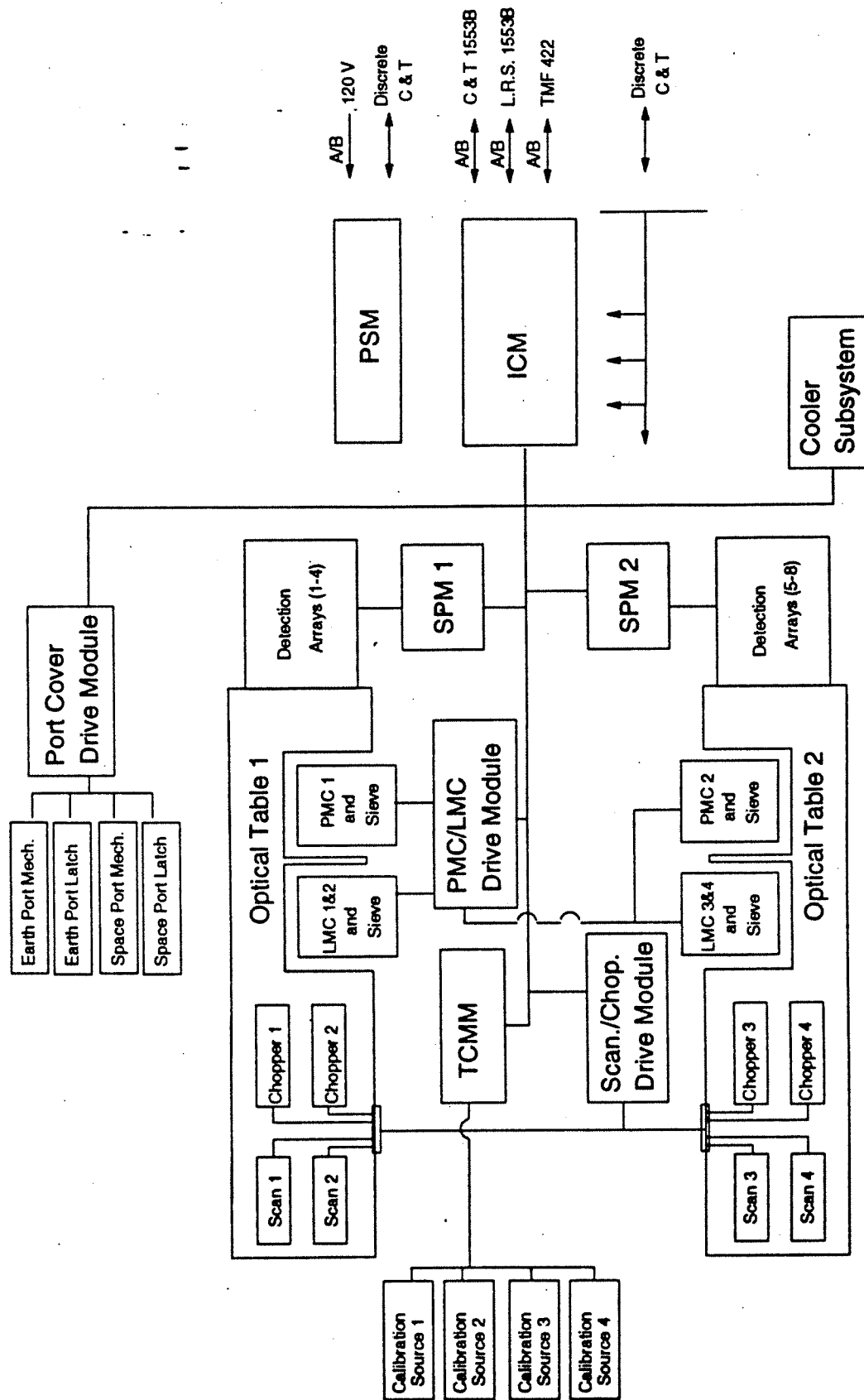


Figure 3.1.1.2-1: MOPITT Instrument Functional Configuration Diagram

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InterfaceReference Designator

Earth Infrared Input	MOP_EIR_IP
Space View-Input	MOP_SPV_IP
Power Supply Discrete Cmd and Tim	MOP_PSM_DCT
Instrument Discrete Cmd and Tim	MOP_INS_DCT
Time Mark and Frequency Bus	MOP_SC_TMF
Command and Telemetry Bus	MOP_SC_BCT
Low Rate Science Output Data	MOP_SC_OP
Power Interface	MOP_SC_PWR
Ground Interface	MOP_SC_GRD
External Thermal Interface	MOP_SC_THE
External Structural Interface	MOP_SC_STR

3.1.2.1.1 Earth Infrared Input (MOP EIR IP)

This interface will be the earth infrared input to the optical sensors within the Instrument. The interface is achieved via the four scan mirrors with the Optical Subsystem.

The interface dimensions are documented in section 3.3.2.3 of AD2, and in RD1.

3.1.2.1.2 Space View Input (MOP SPV IP)

This interface will be the space view of the Instrument to obtain radiation zero during the instrument calibration. The interface is achieved via the scan mirrors of the Optical Subsystem.

The interface dimensions are documented in section 3.3.2.3 of AD2, and in RD1.

3.1.2.1.3 Power Supply Discrete Command and Telemetry (MOP PSM DCT)

This interface consists of discrete (point-to-point) commands from the spacecraft to the Power Supply Module (PSM) of the instrument and discrete telemetry signals from the instrument PSM to the spacecraft. Unless exceptions are identified in RD11, this interface shall comply to AD1 sections 4.5.2, 5.2.3.5, 5.3.2.3, 5.3.3.3, 5.4.2.1.3, 5.4.2.3.2, 5.4.2.4.2, 5.4.3.2, 7.2.1.1, 7.2.1.1.1, 7.2.1.1.2, 7.2.1.2.1.1.

3.1.2.1.4 Instrument Discrete Command and Telemetry (MOP INS DCT)

This interface consists of discrete (point-to-point) commands from the spacecraft to the instrument housing and discrete telemetry signals from the instrument housing to the spacecraft. This interface shall comply with the requirements defined in AD1, sections; 4.5.2, 5.2.3.5, 5.3.2.3, 5.3.3.3, 5.4.2.1.3, 5.4.2.3.2, 5.4.2.4.2, 5.4.3.2, 7.2.1.2.1, 7.3.1.1, unless exceptions are identified in RD11.

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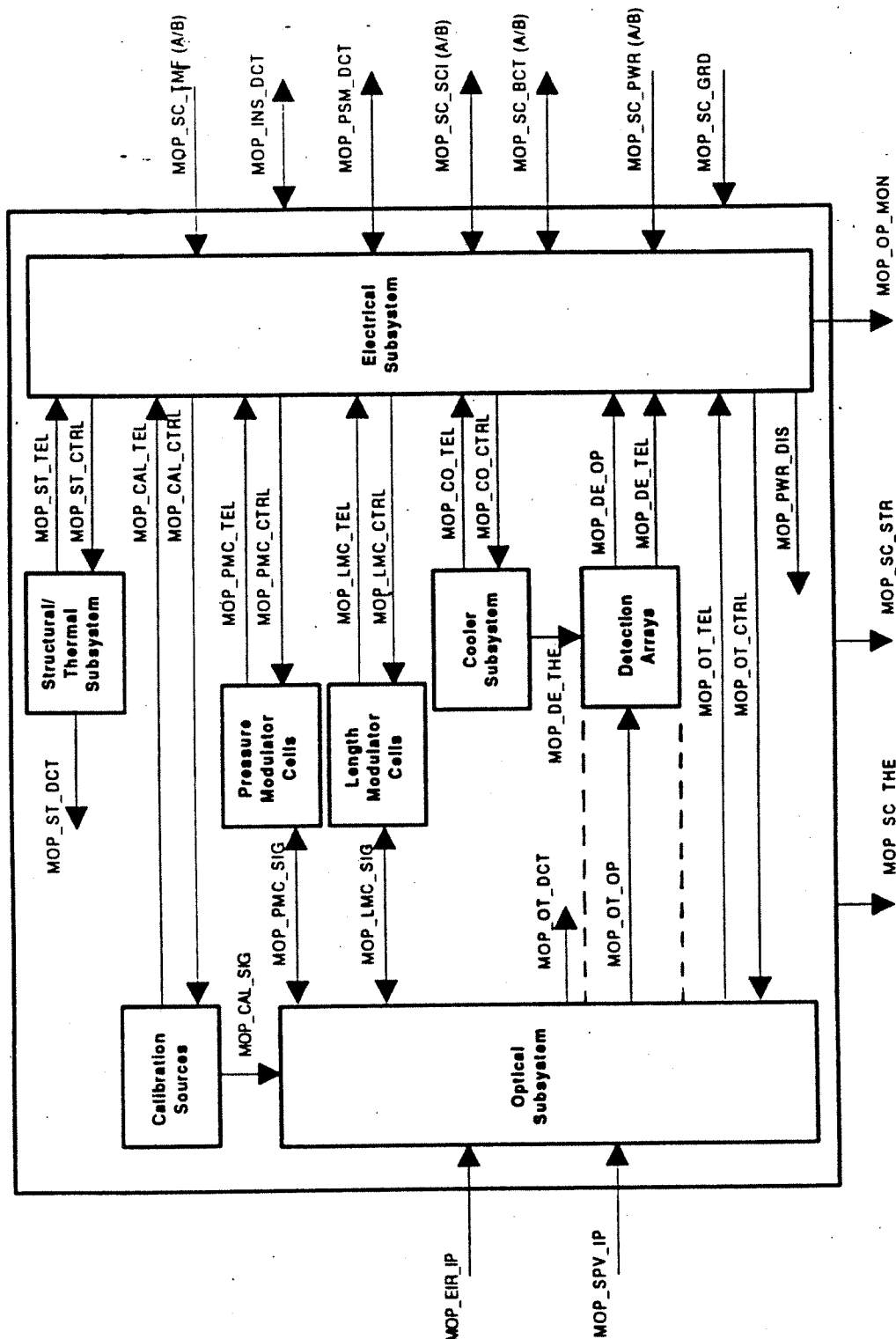


Figure 3.1.2.1-1: MOPITT Instrument External/Internal Interfaces

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3.1.2.1.10 External Thermal Interface (MOP SC THE)

This interface defines the mechanical interface to the instrument coldplate and the radiative field-of-view for the-PSM heat radiator. The radiative interface details will be documented in the Thermal ICD called out by RD1. Unless exceptions are identified in RD11 this interface shall comply with AD1 sections; 3.7.1.2, 3.12.1.1, 3.12.1.2, 3.12.2.1, 3.12.2.2, 3.12.3.1, 3.12.3.2, 4.2.1, 4.2.2, 4.3.1.1, 4.3.2, 4.3.3, 4.3.4, 4.5.3, 4.6.1.4, 4.6.2.1, 4.6.2.2, 4.6.3.1, 4.6.3.2, and AD2 section 5.1.

3.1.2.1.11 External Structural Interface (MOP SC STR)

This interface defines the mechanical interface of the Instrument to the spacecraft. This interface shall be a three point kinematic mount (section 3 of AD1). The pointing accuracy and knowledge requirements are defined in AD2 (section 3.3.3) and AD4 and referenced to the instrument alignment cube and final adjustment is made at the kinematic mounts. Unless exceptions are identified in RD11, this interface shall comply with AD1 sections; 3.5.4.1.3, 3.5.6.1, 3.5.6.2, 3.5.8.1, 3.6.1, 3.6.2.1, 3.6.2.2.

3.1.2.2 Instrument - Major Component Interfaces

The Instrument major component interfaces are listed in this section. Detailed descriptions and specifications for the interfaces are defined by the Instrument Internal Interface Control Document (RD3). The relationship between the interfaces and the major components of the Instrument is shown in Figure 3.1.2.1-1.

<u>Interface</u>	<u>Reference Designator</u>
Optical Science Data	MOP_OT_OP
Optical Subsystem Control	MOP_OT_CTRL
Optical Subsystem Telemetry	MOP_OT_TEL
PMC Optical Signal	MOP_PMC_SIG
PMC Control	MOP_PMC_CTRL
PMC Telemetry	MOP_PMC_TEL
LMC Optical Signal	MOP_LMC_SIG
LMC Control	MOP_LMC_CTRL
LMC Telemetry	MOP_LMC_TEL
Calibration Optical Signal	MOP_CAL_SIG
Calibration Subsystem Thermal Control	MOP_CAL_CTRL
Calibration Subsystem Telemetry	MOP_CAL_TEL
Cooling Subsystem Control	MOP_CO_CTRL
Cooling Subsystem Telemetry	MOP_CO_TEL
Electrical Science Data	MOP_DE_OP
Detection Arrays Thermal Interface	MOP_DE_THE
Detection Arrays Telemetry	MOP_DE_TEL

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3.1.2.1.5 Time Mark and Frequency Bus (MOP SC TMF)

The instrument shall accept a 1.0 MHz reference frequency provided by the spacecraft with an encoded time mark signal on a redundant time mark and frequency bus.

Electrical characteristics of this interface shall comply with EIA-RS-422A.

Time mark will be delivered every 1.024 seconds.

Time mark will be encoded as duty cycle variations on a 2 successive cycles of the reference frequency, maintaining an overall 50% duty cycle. Unless exceptions are identified in RD11 this interface shall comply with the requirements defined in AD1 sections; 5.3.2, 5.3.2.2, 5.3.3.3, 5.4.1.3, 5.4.3.1.

3.1.2.1.6 Command and Telemetry Bus (MOP SC BCT)

This interface consists of command and telemetry bus. Each command and telemetry bus interface shall be dual redundant and individually transformer coupled. Unless exceptions are identified in RD11 this interface shall comply with the requirements defined in AD1 sections; 5.3.3.3, 5.4.1.2.2.1, 5.4.1.2.3, 5.4.1.3, 5.4.4.1.

3.1.2.1.7 Low Rate Science Output Data (MOP SC OP)

This interface provides low-rate science output data. Each low-rate science data interface shall be dual redundant and individually transformer coupled. Unless exceptions are identified in RD11 this interface shall comply with the requirements defined in AD1 sections, 5.3.3.3, 5.4.1.3, 5.4.5, 5.4.5.2.

3.1.2.1.8 Power Interface (MOP SC PWR)

This interface is the primary power input to the Instrument. The spacecraft shall supply instrument power at 120 Vdc $\pm 4\%$. Unless exceptions are identified in RD11 this interface shall comply with the requirements defined in AD1 sections; 5.2.2.11, 5.2.2.1.2, 5.2.2.3.1, 5.2.2.3.3.1, 5.2.2.4, 5.2.2.4.1, 5.2.2.4.2, 5.2.3.3, 5.2.3.4, 5.2.3.5, 5.3.1, 5.3.1.2, 5.3.1.2.2, 5.3.1.2.3, 5.3.1.3.2, 5.3.2.1, 5.3.1.3.3, 5.3.1.3.4, 5.3.4.1.1, 5.3.4.1.2, 5.3.4.1.3, 5.4.1.3.

3.1.2.1.9 Ground Interface (MOP SC GND)

This interface shall provide a connection between the Instrument and the spacecraft ground plane. Unless exceptions are identified in RD11, this connection shall comply with AD1 sections; 5.3.2, 5.3.2.1, 5.3.3.2.1, 5.3.3.2.3, 5.3.3.4.

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3.1.4 Government Furnished Property List

The following equipment are Customer Furnished Equipment:

- a) PMC and PMC sieve (one EQM and three FM units)
- b) Kinematic mounts (one EQM set: both halves) (one FM test set both halves) and(one FM set: instrument half only)
- c) LMC sieve (one EQM and three FM units).
- d) Flight connectors, backshells, connector savers and ESD dust caps (for all external interfaces).

The quantities are TBC.

3.1.5 Government Loaned Property List

The following equipment is Customer Loaned Equipment:

- a) Test cold plate and chiller (one)
- b) Spacecraft interface simulator (one)
- c) Drill templates (one for kinematic mounts and one for coldplate).
- d) Flex blade mounts (one full set)
- e) Instrument-to-Spacecraft breakout boxes

3.2 **Characteristics**

3.2.1 Instrument Performance Requirements

The MOPITT instrument shall be designed to meet the following performance requirements and characteristics.

3.2.1.1 Science Performance Requirements

3.2.1.1.1 Optical Performance

This section describes the optical performance requirements for the MOPITT Instrument.

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Structure/Thermal Subsystem Control
Structure/Thermal Subsystem Telemetry
Power Supply Distribution

MOP_ST_CTRL
MOP_ST_TEL
MOP_PWR_DIS

3.1.2.3 Instrument Diagnostic Interfaces

This Instrument shall provide the interface below to monitor test output signals of the Instrument for diagnostic purposes. Detailed specifications for the interface are defined by the Instrument Interface Control Document (RD3). Unless exceptions are identified in RD11, this interface shall comply with AD1 sections; 5.5.1.1, 5.5.1.2, 5.5.1.3, 5.5.1.4, 5.5.1.5, 5.5.1.6, 5.5.1.7, 5.5.1.8, 5.5.1.9, 5.5.1.10, 3.14.5.8.1, 3.14.5.7.

Interface

Reference Designator

Instrument Output Monitor

MOP_OP_MON

3.1.3 Major Component List

The Instrument shall be comprised of the major components and items listed in Table 3.1.1.2-1.

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3.2.1.1.1.2 Fields of View (FOV)

<u>Number</u>	<u>Characteristic</u>	<u>Value</u>
a)	Total FOV	
	- In nadir view	
	- across track	$\pm 26.1^\circ$ with 1.8° steps (29 positions in total)
	- along track	$\pm 3.6^\circ$
	- In space view	
	- along track	$\pm 0.9^\circ$
	- vertically	$\pm 3.6^\circ$
b)	Instantaneous FOV	
	- In nadir view	
	- across track	$\pm 0.9^\circ$
	- along track	$\pm 3.6^\circ$
	- In space view	
	- along track	$\pm 0.9^\circ$
	- vertically	$\pm 3.6^\circ$
c)	FOV Size Accuracy	the instantaneous FOV size shall not vary from the dimension indicated by more than 10% (TBC).

3.2.1.1.1.3 Boresight Alignment

The Instrument boresight alignment matching requirements define how well corresponding pixels in each of the eight channels shall be aligned relative to each other. All eight channels shall view the same area on the Earth within ± 1.5 km (± 450 arcsec) in 3 standard deviation statistics throughout the scanning range (AD4 section 7.2.1.2).

The boresight accuracy, knowledge and stability definition are illustrated in Figure 3.2.1.1-1.

The boresight alignment accuracy, knowledge and stability requirements, with respect to Earth frame of reference, are defined in Table 3.2.1.1-2 (AD2). This tolerance shall be maintained over the full range of scan system and over the instrument operational lifetime.

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3.2.1.1.1.1 Filter Profiles

The passband of each of the optical beams shall be limited prior to detection. It is necessary to cool these filters to a maximum allowable of 140 K to meet radiometric requirements (additional temperature constraints may be required to maintain filter profile). The filter passbands should be as square as possible and the system transmission, including filters, should be maximized (particularly for the solar channels). The coatings should be protected in the packaging design if possible (facing inward into assembly). The out-of-band attenuation is most critical from 5.6 μm down to 4 μm .

The Instrument should be designed to incorporate eight channels, which are numbered one through eight as described in section 3.1.1. Filter profiles for these channels shall be as shown in Table 3.2.1.1-1.

Table 3.2.1.1-1 Cold Filter Requirements

Filter Designation	Centre Wavelength [μm]	Filter Bandwidth [FWHM in μm]	Cut-off Wavelengths [μm , 5% transmit points]	Peak Transmission (minimum)
Carbon Monoxide: Thermal	4.617 ± 0.022	0.110 ± 0.011	4.548 4.687	70%
Carbon Monoxide: Solar	2.334 ± 0.005	0.022 ± 0.003	2.317 2.351	50%
Methane: Solar	2.258 ± 0.015	0.071 ± 0.007	2.213 2.302	55%
Notes:	Tolerances and shape parameters are TBC. Centre wavelength accuracy = $\pm 20\%$ of bandwidth. Filter bandwidth accuracy = $\pm 10\%$ of bandwidth. All coating and substrate materials shall be non-hygroscopic. Out-of-band blocking shall extend from 1.5 micron to 6.0 microns wavelength and shall be 10^{-5} (TBC).			

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The boresight alignment and co-alignment budgets are shown in Table 3.2.1.1-3 and Table 3.2.1.1-4 respectively. This budget shall be maintained over the full range of scan system and over the instrument operational lifetime.

Table 3.2.1.1-3: Boresight Alignment Budget

Ref.	Source	Accuracy (arcsec, 0-p, 3 sig.)			Knowledge (arcsec, 0-p, 3 sig.)			Jitter (arcsec, p-p, 3 sig./12.5 s)		
		Roll	Pitch	Yaw	Roll	Pitch	Yaw	Roll	Pitch	Yaw
1	Scan Motor to optical table	200	90	90	100	90	90	100	90	90
2	Optics boresight to chassis	60	60	60	60	60	60			
3	Optical chassis to baseplate static	50	25	50	0	0	0			
4	Optical S/S & baseplate dynamic and thermal	25	60	25	25	60	25			
5	Array Rotation	0	0	90	0	0	0			
6	*	0	0	60	0	0	0			
7	**	0	0	200	0	0	0			
	RSS (1-7)	216	126	257	119	123	111	100	90	90
	S/C to IRC	150	150	150	90	90	90	65	65	65
	Requirement	500	500	500	300	300	300	322	322	322
	Margin (RSS Instrument and S/C then linear subtraction from requirement, per UIID)	237	304	202	150	147	157	202	210	210
* the IAC to DAF cube errors will be adjusted out to meet requirement at the s/c level for the pitch and roll directions.										
The IAC to DAF cube alignment requirements are defined elsewhere, this table shows the residual effect of these errors.										
** the IAC to baseplate errors will be adjusted out to meet requirement at the s/c level for the pitch and roll directions.										
The IAC to baseplate alignment requirements are defined elsewhere, this table shows the residual effect of these errors.										

Table 3.2.1.1-4: Boresight Co-Alignment Budget

Pixel to Pixel Co-location Between Channels								
Ref.	Source	Accuracy (arcsec, 0-p, 3 sig.)			Knowledge (arcsec, 0-p, 3 sig.)			
		Roll	Pitch	Yaw *	Roll	Pitch	Yaw *	
1	Scan Motor 1	200	90	N/A	100	90	N/A	
2	Scan Motor 2	200	90	N/A	100	90	N/A	
3	Array 1 Rotation	90	0	N/A	90	0	N/A	
4	Array 2 Rotation	90	0	N/A	90	0	N/A	
5	1	60	60	N/A	60	60	N/A	
6	2	60	60	N/A	60	60	N/A	
7	Optical chassis to baseplate static 1	50	25	N/A	10	10	N/A	
8	Optical chassis to baseplate static 2	50	25	N/A	10	10	N/A	
9	Optical S/S & baseplate dynamic and thermal 1	25	60	N/A	25	60	N/A	
10	Optical S/S & baseplate dynamic and thermal 2	25	60	N/A	25	60	N/A	
	RSS (1-10)	331	178	N/A	211	175	N/A	
	Requirement (TBC)	450	450	N/A	450	450	N/A	
	Margin	119	272	N/A	239	275	N/A	
* errors in the channel yaw direction are coupled into pitch and roll components for pixel co-alignment								

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Table 3.2.1.1-2: Boresight Alignment Requirement (TBC)

	Accuracy [arcsec 3σ]			Knowledge [arcsec 3σ]			Stability [arcsec $3\sigma/\Delta t[s]$]		
	R	P	Y	R	P	Y	R	P	Y
Requirement	1800	1800	1800	300	300	300	322/12.47	322/12.47	322/12.47

R - Roll (about X axis)

P - Pitch (about Y axis)

Y - Yaw (about Z axis)

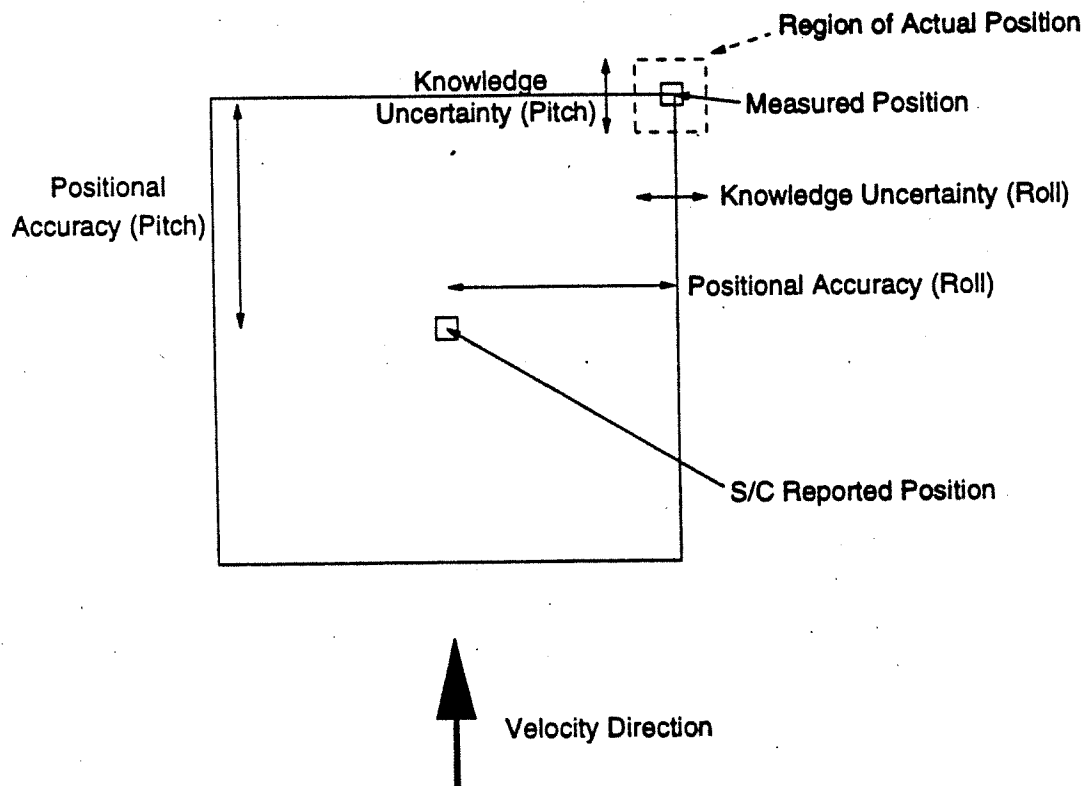


Figure 3.2.1.1-1: Boresight Accuracy and Knowledge Definition.

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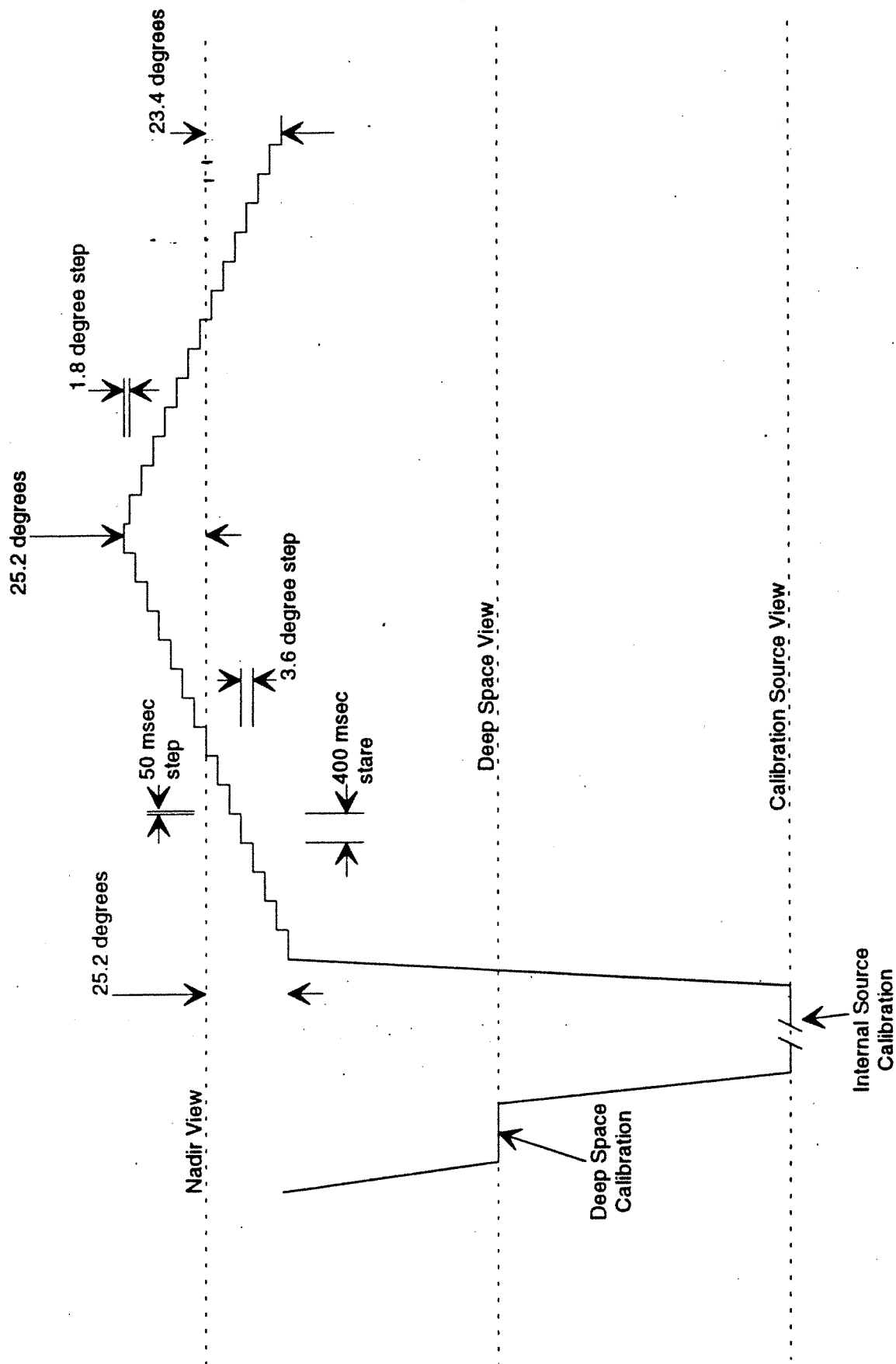


Figure 3.2.1.1-2: MOPITT Instrument Typical Scanning Sequence

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3.2.1.1.1.4 Scanning Implementation

The scan mirror is required to provide wider cross-track coverage. The scan mirror shall always be in the optical path, even during calibration sequences (and it is desirable that no other elements are introduced in the calibration process). The same part of the mirror should be kept in the beam during observations. The observations shall be performed when the mirror is mechanically stable (amplitude of motion < TBD arc sec). The settling time after stepping should be minimized, as defined below. The temperature of the scan mirror shall be monitored as per Table 3.1.1.1-4. The scan steps must be repeatable to within the required precision which is governed by the pointing and co-alignment requirements. The mirror should be passively thermally stabilized by using a high emittance coating on the rear side.

A typical scanning sequence should consist of the following operations: Space view to obtain radiation zero, Internal view of calibration target to establish response to a known radiance, followed by a series of Earth scanning views. This sequence is illustrated in Figure 3.2.1.1-2. This sequence is the standard operating mode of the Instrument and is normally maintained for the entire life of the instrument. The swath width, stare period and calibration intervals shall be programmable. During normal operations the scan mirrors should step together to the extent necessary to ensure the co-location requirement is satisfied. Typical scanning time for each parameter is as follows.

<u>Number</u>	<u>Characteristic</u>	<u>Value</u>
a)	Space View Scanning	30-300 seconds
b)	Internal View Scanning	30-300 seconds
c)	Earth Staring	0.400 seconds
d)	Earth Stepping/Settling	0.054 seconds per step
e)	Earth Scanning	13.17 seconds per swath (29 stares)

The duration and frequency of calibrations will be determined by gain/thermal stabilities and noise levels.

3.2.1.1.1.5 Chopper Performance Requirements

The beam shall be full aperture chopped with an approximately trapezoidal waveform. The chopper rate must be stable and synchronized with the instrument timing control circuitry. Each chopper shall provide an encoder signal that represents the chop waveform frequency. The temperature of the chopper shall be monitored as per Table 3.1.1.1-4.

The optical beam in each channel shall be fully chopped at a programmable frequency over the range of 460 Hz to 620 Hz. The chopper blade shall have a reflectivity (for longwave channel band) of < 0.2 (TBC).

The edge of the blade teeth shall be tapered at angle larger than the optical ray angle. The small opening side of the blade shall face the detector.

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Table 3.2.1.1-5 Channel Optical Transmission Requirements
(Not Including Contamination After Delivery for Instrument Assembly)

Channel	Minimum LMC Double-Pass Transmission at End of Life	Minimum Optical S/S Transmission at End of Life	Minimum Total Optics Transmission at End of Life
1	0.696	0.386	0.266
2	0.696	0.295	0.203
3	0.864 (PMC SP)	0.418	0.366
4	0.696	0.299	0.206
5	0.696	0.386	0.266
6	0.696	0.288	0.199
7	0.864 (PMC SP)	0.410	0.359
8	0.696	0.299	0.206

* Excluding gas absorption

3.2.1.1.1.7 Stray Light

Stray light is defined as the signal component which is not due to the "scene", for the chopper open case. The "scene" could be the Earth, the onboard calibration source or the view to cold space.

Stray light from external or internal sources should be minimized. The entrance apertures shall be baffled to minimize solar or scattered solar radiation from entering the scanning optics cavity or directly illuminating an optic. The chopper aperture shall be masked with oversized baffles on both sides of the chopper. The optical paths in the instrument should be enclosed in a nearly light tight nearly isothermal wall. The enclosure should have low reflection ($R < 0.1$ TBC) interior coatings. Pixel to pixel crosstalk within a channel should be less than 10% (TBC).

3.2.1.1.2 Gas Correlation Performance

The gas correlation filtering must be implemented to accommodate very low pressures and very high pressures. This will require two types of mechanisms; a pressure modulator cell (PMC) and a length modulator cell (LMC). The PMC is to be supplied as GFE. The LMC should be implemented so that the optical properties are as much as possible identical in all states. A sieve shall be attached to the carbon monoxide gas sample chamber to maintain and adjust the gas pressure as required. The

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3.2.1.1.1.6 Imaging Performance

The optical beam diameter and shape shall be controlled to allow the proper interaction of the beam with the various mechanisms (scan mirror, chopper, and LMC or PMC). A double pass configuration is required for each LMC. The field stop shall be the detector array active area. The aperture stop shall be a cryogenically cooled surface. The final image shall match the detector size to the required FOV. The image plane should be shifted slightly out of focus to reduce FOV motion induced edge noise (see AD4 section 7.2.1.9).

The optical image quality shall have the following performance characteristics.

<u>Number</u>	<u>Characteristic</u>	<u>Value</u>
a)	Pixel Image (Detection Element) Size	1.8° × 1.8° FOV (0.9 mm × 0.9 mm)
b)	Transmission	see table 3.2.1.1-5
c)	Encircled Energy	35 μm < 80% encircled diameter < 55 μm (TBC AD4 section 7.2.1.9)
d)	Distortion	< 2.6 % in field angle (TBC)
e)	Entrance Pupil Diameter	As Required ²
f)	Polarization Balance	< 10% (TBC AD4 section 7.2.1.11)
g)	Polarization Determination	< 1% (TBC AD4 section 7.2.1.11)

2

The entrance optics diameter will be slightly over-sized relative the limiting aperture defined by the cold stop. The cold stop must define a field-of-view for the detector greater than one steradian..

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**Table 3.2.1.1-6: Summary of Channel Performance Requirements (Difference-Band)
For The MOPITT Instrument**

Channel	Precision Equivalent Radiance [$\mu\text{W}/\text{m}^2/\text{sr}$]	In-Band Scene Radiance (Nominal) [$\mu\text{W}/\text{m}^2/\text{sr}$]	In-Band Scene Radiance (Max) [$\mu\text{W}/\text{m}^2/\text{sr}$]
1	< 84.0	129000	793000
2	< 2.69	42300	213000
3	< 55.0	132000	793000
4	< 10.6	131000	846000
5	< 68.0	108000	793000
6	< 3.48	42000	213000
7	< 23.4	133000	793000
8	< 10.6	131000	846000

Notes : 1) The "Precision Equivalent Radiance" (PER) is from the AD4 (Table 7.3).

The average band performance requirements are TBD.

3.2.1.1.4 Calibration Performance

Each channel requires two known input radiances to determine the response. A zero input case is achieved by rotating the scan mirror to view deep space. A second radiance is achieved by having onboard references, one per scan mirror. The onboard reference shall be capable of normally operating near 300 K, but during long calibration (approximately every 30 days) the temperature shall be increased to approximately 500 K.

Time sequence for instrument calibration is shown in Figure 3.2.1.1-1. Reference targets used in the calibration shall allow the following performance characteristics.

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internal pressure shall be monitored, using a sensor for each LMC and using a resonance measurement technique for each PMC.

The LMC pressure monitoring accuracy shall be $\pm 2\%$ (TBC). The resolution shall be 11 pascals (TBC), the monitor drift between calibrations (up to 30 days) shall be less than TBD.

The LMCs shall have a length modulation of approximately 5:1 (specifically 10 mm : 2mm) +/- TBD.

The LMC rotation rate should be constant and programmable in the 550 -834 RPM range.

The PMCs shall have a pressure modulation of approximately 2:1 (specifically 2.5 kPa/5 kPa, and 5 kPa/10 kPa) +/- 20% (TBC).

The modulation cells shall have an optical balance that can be determined within the limits in section 3.7 over the entire mission. The total optical unbalance term should be minimized per rotation.

The internal gas pressures, gas correlation cell type and gas species for each channel are defined in Table 3.1.1.1-1.

The PMC should be accommodated optically in the narrowest part of the beam.

The PMC pistons should be maintained at constant amplitude which shall be programmable.

The sieves shall not be removed or detached during installation.

The sieve heaters shall be programmable with TBD resolution by the software in an open loop.

3.2.1.1.3 Radiometric Performance

The Instrument should be designed to incorporate eight channels. Each channel shall have its own detector which consists of a four by one array. The signal from each pixel in the array is called a sub-channel. The sub-channel digitized signal (averaged over each channel) shall meet the performance requirements that are defined in Table 3.2.1.1-6.

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Table 3.2.1.2-1 : MOPITT Instrument Modes and Nominal Hardware States

Item	MOPITT Mode						
	Off	Launch	Survival	Boot	Safe	Standby	Science
C&T bus communications	--	--	--	YES	YES	YES	YES
LRS bus communications	--	--	--	--	NO/ yes	YES	YES
Prime power	OFF	ON	ON	ON	ON	ON	ON
Survival Rails	OFF	ON	ON	ON	ON	ON	ON
Secondary Rails	OFF	LAUNCH	OFF	ON	ON	ON	ON
Port Covers	CLOSED	CLOSED	CLOSED (TBC)	OPEN or CLOSED	OPEN (TBC)	OPEN/ closed	OPEN/ closed
Scan Mirrors	DISABLED (parked)	DISABLED (parked)	DISABLED (parked)	DISABLED (parked)	DISABLED (parked)/ enabled	ENABLED (parked)/ disabled	ENABLED /disabled
Choppers	OFF	ON (LAUNCH)	OFF	OFF	OFF/ on	ON/ off	ON/ off
LMCs	OFF	ON (LAUNCH)	OFF	OFF	OFF/ on	ON/ off	ON/ off
PMCs	OFF	OFF	OFF	OFF	OFF/ on	ON/ off	ON/ off
Coolers	OFF	OFF	OFF	OFF	OFF/ on	ON/ off	ON/ off
Mission Critical Heater Monitoring	OFF	OFF	OFF	OFF	ON	ON	ON
Voltage Monitoring	OFF	OFF	OFF	OFF	ON	ON	ON
Current Monitoring	OFF	OFF	OFF	OFF	ON	ON	ON
Thermal monitoring	OFF	OFF	OFF	OFF	ON	ON	ON
SPMs	OFF	OFF	OFF	DISABLED	DISABLED/ enabled	ENABLED/ disabled	ENABLED/ disabled

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<u>Number</u>	<u>Characteristic</u>	<u>Value</u>
a)	Thermal Channel	
	- wavelength	4.6 μm
	- temperature	300 K (nominal)
	- accuracy ³	± 0.2 K
b)	Sunlight Channels	
	- wavelength	2.3 μm
	- temperature	500 K (nominal)
	- accuracy ³	± 0.5 K

3.2.1.2 Instrument Operating Modes

The MOPITT instrument modes are defined in a manner that is compatible with the instrument embedded software development. This section provides an overview of instrument modes, a detailed description is available in RD13.

The instrument mode definitions are based on the various operating "states" of the instrument. To be consistent with EOS terminology, these "states" will be called modes. Table 3.2.1.2-1 defines the MOPITT instrument modes and the various states for each mode. Details of instrument operations on orbit are documented in RD12.

- Off Mode
- Launch Mode
- Survival Mode
- Boot Mode
- Safe Mode
- Operational Mode
 - Standby Mode
 - Science Mode
 - Science Scan Procedure
 - Science Long Calibration Procedure

The nominal state for each hardware item by mode is summarized in the following table.

³

The accuracy is expressed as a radiometric equivalent brightness temperature and includes all uncertainties, such as; temperature measurement uncertainties, emissivity uncertainties, and reflected energy (due to non-unity emissivity) uncertainties.

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- check-out functions
- program functions

Figure 3.2.1-2.1-1 illustrates the relationships between operating modes of the instrument.

3.2.1.2.2 Spacecraft System Mode Relationship To Instrument Mode

The various spacecraft system modes which are defined in AD1 (and its reference handbook) and listed below:

1. Launch Mode
2. Science Mode
3. Delta-V Mode
4. Survival Mode
5. Safe Mode

Within each of these spacecraft system modes the instrument will have its own mode defaults and valid modes. These are defined in Table 3.2.1.2.2-1.

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3.2.1.2.1 Instrument Operating Mode Descriptions

Off Mode

The instrument 120 Vdc supply is powered off in this state. This mode is corresponding to the spacecraft ground OFF mode and is not valid during the launch and on-orbit segments.

Launch Mode

This mode is required to protect the various mechanisms in the instrument. The details of this mode are defined in RD12.

Survival Mode

This is a low power mode of the instrument. Only survival equipment is powered ON. The 120 Vdc is powered to the instrument but the operational power supplies are turned off. This mode corresponds to the spacecraft system mode: survival. On entering this mode from Safe mode or Operational mode, stable condition shall be reached within 30⁴ seconds.

Boot Mode

Boot mode is used by the ICM computer to load program code if desired.

Safe Mode

This is a non-operational mode, i.e. non-science data generating mode. It is configured to provide no damage to the instrument caused by sudden loss of operating power. Full power is available to the instrument in this mode.

Operational Mode

This is the science operation mode of the instrument. Full power is available to the instrument. It consists of standby and science modes.

During the operational mode the procedures/functions that can be invoked include the following:

- port cover procedures
- scan procedure (swath, duration, short cal. period)
- long calibration procedure
- evaporate procedure

⁴ The 30 second requirement originates in section 7.5.2.2.2 of AD1.

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Table 3.2.1.2.2-1: Spacecraft System Mode versus Instrument Mode

Instrument Mode	Spacecraft System Modes				
	Launch Mode	Delta-V Mode	Science Mode	Survival Mode	Safe Mode*
Off Mode	P1				
Launch Mode	P5				
Survival Mode	P2	P1	P1	P1	
Boot Mode	P3		P2		
Safe Mode	P4		P3, B		P1
Standby Mode			P4, B		
Science Mode		P1**	P5		
Notes: "Px" represents primary mode and normal sequence of mode transition. "B" represents backup mode(s). * Sun pointing or SCC down or thruster control, only. ** This mode only applicable when the spacecraft enters from Science Mode.					

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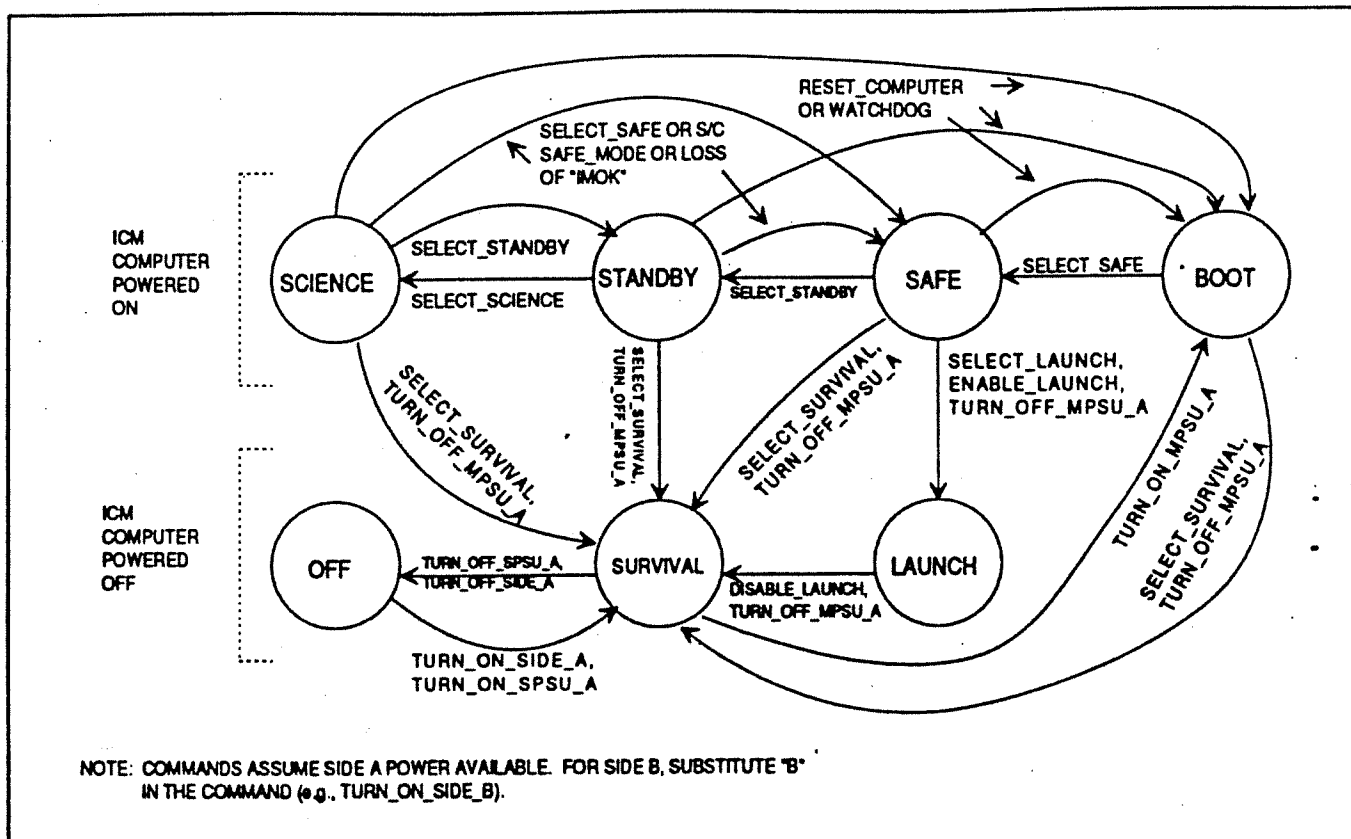


Figure 3.2.1.2.1-1 : MOPITT Instrument Operating Modes

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3.2.1.4.2 Power Characteristics

The Instrument shall survive, operate and perform when subjected to power characteristics defined in section 5.2.2 of AD1.

3.2.1.4.3 Power Budget

Table 3.2.1.4-2 shows the allocation of power (TBC) to the instrument subsystems or modules not including contingency, this table does not include failures or partial failures.

Table 3.2.1.4-2 MOPITT Instrument Power Budget Per Mode (TBC)

Power [W]	Science Scan	Science Long Cal.	Survival	Standby	Safe	Launch
Cooler S/S	71.0	71.0	0	71.0	71.0	0
TCMM	12.3	13.6	0	12.3	12.3	0
ICM	14.8	14.8	0	14.8	14.8	0
PSM	41.8	42.7	43	41.8	41.8	7.6 (TBC)
SPM (total)	14.2	14.2	0	14.2	14.2	0
Optical S/S	17.0	10	0	17.0	10	8.5 (TBC)
PMC & drive*	12.0	12.0	0	12.0	12.0	0
LMC & drive*	25.5	25.5	0	25.5	25.5	22.0 (TBC)
Structural/ Thermal S/S	0.3	0.3	8 (TBC)	0.3	0.3	0
Cal. Sources	0	9.6	0	0	0	0
Total	208.8	213.5	51 (TBC)	210.1	199.6	38.1(TBC)

* includes molecular sieves.

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3.2.1.3 Command and Telemetry Lists

The MOPITT Command and Telemetry Lists shall be compliant with the requirements in AD1 section 6 and 7 unless exceptions are identified in RD11.

The C&T list shall be documented in RD14 and RD1.

MOPITT discrete command interfaces shall not exceed 20 relay drive. MOPITT discrete telemetry shall not exceed 16 passive bi-level, and 21 passive analog interfaces (as per 3.1.4 of AD2).

3.2.1.4 Power Requirements

3.2.1.4.1 Primary Power Allocation

The MOPITT primary power allocations are documented in AD2, (including the required contingency) and are listed in Table 3.2.1.4-1.

Table 3.2.1.4-1 MOPITT Instrument Primary Power Allocation

Instrument Mode	Average Power (W)	Peak Power (W)
Launch	51	51
Survival	43	43
Operational	250	250

Average power is defined as the average power utilized by the instrument over any 1-orbit period commencing with the crossing of the night-to-day terminator. Peak power is defined as the maximum power required by the instrument, not including transients (repetitive or non-repetitive) with a duration less than 20 milliseconds.

Remaining power contingency shall be ≥20 % up to and including PDR, ≥10 % (TBC) up to and including CDR, and ≥5 % (TBC) up to and including instrument delivery. This contingency is defined as follows:

$$\text{Percent Remaining Contingency} = \frac{\text{Allocation} - \text{Current Estimate}}{\text{Baseline Estimate of 205W}} \times 100\%$$

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3.2.2 Instrument Physical Characteristics

3.2.2.1 Physical Description

The Instrument consists of many modules all mounted to a single baseplate, all but the PSM are enclosed in a single box, approximately rectangular in shape. The instrument outline is shown in Figure 3.2.2.1-1. The optical equipment shall utilize eight viewing ports; four open in the nadir surface to view the earth (earth view) and four open on the anti-sun surface to provide a radiation zero for the instrument (space view). Deployable covers shall be used to seal these ports during I&T and launch.

3.2.2.2 Mass

The total mass of the Instrument shall be less than 184 kg (section 3.3.1.1 of AD2).

A mass contingency shall apply to the instrument excluding the mass of the baseplate (ie. baseplate has no contingency). Remaining contingency shall be ≥15 % up to and including PDR, ≥10 % (TBC) up to and including CDR, and ≥5 % (TBC) up to and including instrument delivery. This contingency is defined as follows:

$$\text{Percent Remaining Contingency} = \frac{\text{Allocation Excluding Baseplate} - \text{Current Estimate Excluding Baseplate}}{\text{Baseline Estimate Excluding Baseplate of 100 kg}} \times 100\%$$

The instrument, while on-orbit, shall not have any mass variability.

3.2.2.3 Mass Budget

The MOPITT Instrument mass budget is defined in Table 3.2.2.3-1. Mass budget does not include margin for each line item. Mass contingency is held at the instrument level.

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3.2.1.5 Data Rate Requirement

The MOPITT data rate budget is defined in Table 3.2.1.5-1 for the various instrument modes, which are defined in AD1.

- - - Table 3.2.1.5-1: MOPITT Instrument Data Rate Budget

Instrument Mode	C & T Bus Rates (kbps)					Science Bus (kbps)
	Command & Memory Load ¹	Ancillary Data ²	Normal Housekeeping Telemetry	Critical Health & Safety Telemetry	Memory Dump ¹	
Launch	0	0	0	0	0	0
Survival	0	0	0	0	0	0
Safe	64	0.5	0.5	0.03	0.5 to 10.67	25 or 0 (TBC)
Operational	64	0.5	0.5	0.03	0.5 to 10.67	25

¹ Total rate for spacecraft and peak rate for instrument.

² Includes IMOK, time code data, and safe mode commands.

The specified science data rate includes all CCSDS packetization overhead and applies as both an average allocation and a peak allocation. Average science data rate is defined as the average over any 1-orbit period commencing with the crossing of the night-to-day terminator.

The average science data rate shall not exceed 25 kbps (AD2 section 3.1.1.2).

The peak science data rate shall not exceed 40 kbps (AD2 section 3.1.1.3 as defined by the T2P requirements (AD1 section 6.3.5.7.3)).

The MOPITT Instrument is allocated the aggregate data rate of 16 bps for critical health and safety telemetry. This data is collected via the discrete telemetry interfaces (Passive Bi-Level and Passive Analog Telemetry), and via the command and telemetry bus (4 bps maximum) (AD2 section 3.1.1.6).

The MOPITT instrument is allocated the data rate of 32 bps for the normal housekeeping telemetry collected via the discrete telemetry interfaces (Passive Bi-Level and Passive Analog Telemetry) (AD2 section 3.1.1.7).

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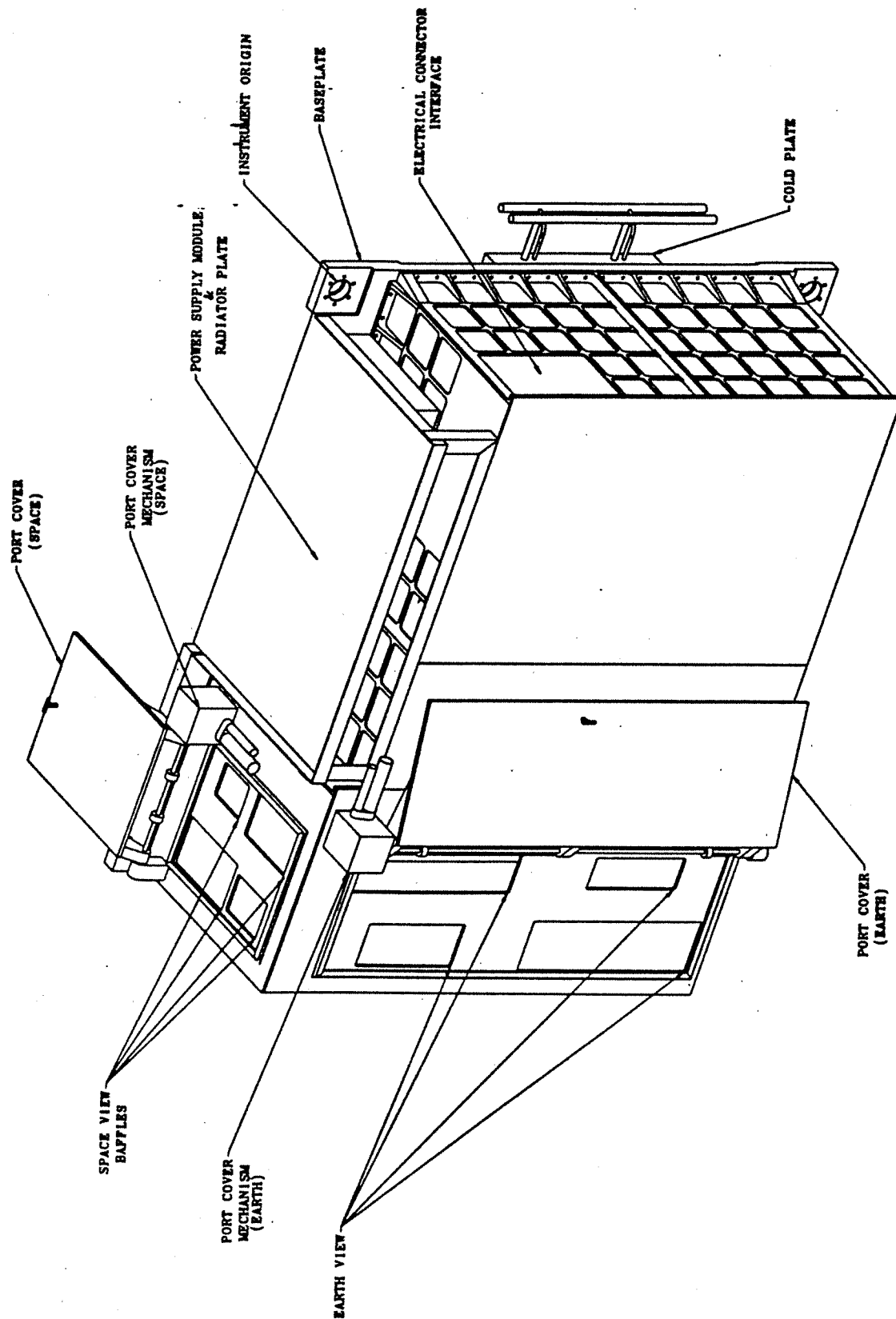


Figure 3.2.2.1-1: MOPITT Instrument Physical Outline Concept

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Table 3.2.2.3-1 MOPITT Instrument Mass Budget (TBC)

Subsystem/Module	Allocated Mass [kg]
Cooler S/S	21.1
Electronics Modules	21.3
Optical S/S	26.1
PMC Assemblies	4
LMC Assemblies	9.6
Structural/Thermal S/S	80.5 (including baseplate of 50.0)
Cal. Sources	4.0
Total	166.5

3.2.2.4 Size

The instrument size (documented in RD1) shall be contained within an approximate volume of 1142 mm (length) × 930 mm (width) × 525 mm (height), including the mounting feet, but not including calibration source protrusions.

The instrument envelope including FOV volumes (for launch and operational) shall be as defined in RD1 and AD2.

3.2.2.5 Center of Mass

The center of mass shall be measured or calculated with respect to the reference coordinate system to the accuracy specified in section 4.5. The individual centers of mass in all three planes for units intended for qualification, flight and flight spare shall not vary by more than 5% (TBC) from each other.

3.2.2.6 Moments of Inertia and Products of Inertia

The moments of inertia shall be measured or calculated with respect to the reference coordinate system, to the accuracy specified in section 4.5.

The products of inertia shall be measured or calculated with respect to the reference coordinate system, to the accuracy specified in section 4.5.

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$$M.S. = \left(\frac{\text{Allowable Stress}}{\text{Maximum Calculated Stress} * \times \text{Factor of Safety}} - 1 \right) \times 100\% > 0$$

- * - Including any applicable stress concentrations factors.

The allowable stress is the allowable stress (yield or ultimate) obtained from an approved source. The maximum calculated material stress is that stress induced by qualification level loads. In considering the loads on the structure during launch, the following sources of structural loads must be considered as a minimum:

- sine and random vibration
- acoustic noise
- pressure differential (use twice the expected pressure differential)
- mechanical shock (TBC)

The applicable Factors of Safety are as follows:

- Factor of Safety against Yield = 1.1
- Factor of Safety against Ultimate = 1.4
- Factor of Safety against Buckling = 1.4
- Factor of Safety for fasteners = 1.5

3.2.2.8.2.2 Fatigue

Fatigue stresses shall be evaluated using Miner's Rule where a cumulative fatigue damage ratio (Rn) is calculated as follows:

$$Rn = \frac{n_1}{N_1} + \frac{n_2}{N_2} + \frac{n_3}{N_3}$$

Where $Rn \leq 0.7$ (Ref. RD9).

3.2.2.9 Unbalanced Forces, Torques and Angular Momentum

The unbalanced forces, torques and angular momentum within MOPITT due to mechanisms shall be less than the levels documented in AD1 section 3.7.6.2, inclusive unless noted in RD11. All mechanism disturbances shall be documented in RD1.

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3.2.2.7 Venting

- a) All non-hermetic cavities in the instrument shall be designed to vent upon launch, without structural degradation, when subjected to the launch pressure profile detailed in section 3.2.5.2.5.
- b) The ratio of volume vented to aperture area shall not exceed 250 000 mm with no individual aperture being less than 0.7 mm² unless a venting analysis is performed.
- c) The instrument shall be designed so that gases vented during ascent and on-orbit will be directed away from contamination sensitive surfaces of the MOPITT instrument and of adjacent instruments on the spacecraft as defined in RD7.
- d) The venting forces and impulses shall comply with section 3.11 inclusive, unless noted in RD11.

3.2.2.8 Mechanical Requirements

3.2.2.8.1 Stiffness

The fundamental instrument mode shall not be less than 35 Hz (section 3.7.2, AD1). The design goal is 70 Hz.

Instrument and module modes within 5 Hz (TBC) of any mechanism operating frequency, shall be identified and reviewed with system engineering. The baseline frequency ranges are;

- 40-53 Hz (PMCs)
- 43-45 Hz (Coolers)
- 10-14 Hz (LMCs)
- 20-30 Hz (Choppers)

3.2.2.8.2 Strength

3.2.2.8.2.1 Safety Margins

The instrument shall be designed to withstand the environmental conditions of Section 3.2.5 with positive margins of safety based on material properties from approved sources. The margin of safety shall be calculated as follows:

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3.2.5 Environmental Conditions

The instrument shall be designed to operate in the specified environmental conditions such that no performance degradation occurs beyond the specified limits, defined in section 3.2.1.1, during the design life described in section 3.2.3.1.

3.2.5.1 Temperature

The instrument mounting interface (spacecraft side of kinematic mount) temperatures, for start-up, acceptance, qualification and non-operating (survival) are defined in Table 3.2.5.1-1 (AD1 section 4.4.1). The instrument shall perform during and following exposure to these operating, start-up and non-operating temperatures.

Table 3.2.5.1-1 Instrument Operating, Non-operating and Start-up Interface Temperatures

Temperatures (°C)	Min	Max
Non-operating (Survival)	-23	+50
Start-up	-23	N/A
Acceptance	0	+30
Qualification	-5	+35

The instrument has a spacecraft-supplied coldplate mounted to it. The temperature ranges for this plate are given in Table 3.2.5.1-2. The temperature range for the coldplate during operation is 20°C to 25°C (AD1 section 4.4.2.1 and RD16).

Table 3.2.5.1-2 Operating, Non-operating and Start-up Coldplate Interface Temperatures

Temperatures (°C)	Min	Max
Non-operating (Survival)	-23	60
Start-up	-23	N/A
Acceptance	+15	+30
Qualification	+10	+35

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3.2.2.10 Pressurized Systems

Pressurized systems within the MOPITT instrument shall comply with section 3.7.5 of AD1 unless noted in RD11.

3.2.2.11 Torque Margin

Mechanisms within the instrument should have a torque margin consistent with program guidelines (RD17).

3.2.3 Design Life and Reliability

3.2.3.1 Design Life

Flight MOPITT instrument shall be designed to survive and function within specification over the following duration:

- a) Complete ground AI&T program of 1.5 (TBC) years.
- b) Storage (unpowered) for 2 (TBC) years.
- c) Mission operational life of 5.0 years (AD4).

3.2.3.2 Reliability

The Instrument shall be designed to comply with the reliability requirement as outlined in section 7.1.3 of AD4.

The mean time between failure (MTBF) of the Instrument shall be predicted by analysis as defined in AD5.

3.2.4 Maintainability

The Instrument design shall be such that a minimum of special tools and test equipment are required to perform adjustments and accomplish fault identification.

The Instrument shall be designed for installation and removal from the EOS platform without any disassembly of the instrument.

No scheduled and preventative maintenance shall be required.

Purging will be used during I&T (see RD7).

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3.2.5.2.3 Sine Vibration

Table 3.2.5.2.3-1 defines the sine vibration load limits for the instrument. The instrument shall meet the design load limits (section 3.4.3 of AD3) and be subjected to the test limits specified. These levels apply at the mounting interface of the instrument.

Table 3.2.5.2.3-1 Instrument Sine Vibration Levels

Frequency (Hz)	Qualification Test Limits	Acceptance Test Limits
5-9	0.5 inch DA	0.5 inch DA
9-50	± 2 g	± 1.6 g
Duration:	2 oct/min 4 oct/min (Protoflight)	4 oct/min

Note: DA = Double Amplitude (peak to peak)

3.2.5.2.4 Shock

The Instrument shall meet performance requirements following exposure to the shock environment specified in Figure 3.2.5.2.4-1. The peak level in Figure 3.2.5.2.4-1 corresponds to 580 G. These level applies at the mounting interface of the instrument.

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3.2.5.2 Vibration and Shock

3.2.5.2.1 Launch Limit Loads

Limit load of 12 g's shall be applied at the centre of mass (CM) of the instrument and instrument accommodation equipment components, configured for launch, to design the mounting interface.

The loads shall be applied in one axis at a time and in such a way as to produce maximum stresses.

3.2.5.2.2 Random Vibration

The instrument interface design shall be consistent with the random vibration levels as defined in Table 3.2.5.2.2-1. These levels apply at the mounting interface of the instrument. The test duration is one minute for acceptance and two minutes for qualification.

Table 3.2.5.2-1 Instrument Random Vibration Levels

Frequency (Hz)	Test Level (g ² /Hz)
20	0.010
20-50	+4.6 dB/octave
50-800	0.040
800-2000	-4.6 dB/octave
2000	0.010
Overall g _{rms}	12

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3.2.5.2.5 Launch Pressure Profile

The instrument shall be designed to withstand a maximum atmospheric decay rate of 0.5 (TBR) psi/sec except for a short perturbation, not exceeding three seconds in duration, where the rate of decay will not exceed 0.76 (TBR) psi/sec. The instrument shall withstand the partial pressures during launch without corona discharge.

3.2.5.2.6 Acoustics

The instrument shall be designed to withstand acceptance and qualification/protoflight acoustic levels as defined in Tables 3.2.5.2.6-1 and 3.2.5.2.6-2.

3.2.5.2.7 Acceleration

The instrument shall be designed to withstand a maximum acceleration of 0.015 G on orbit without degradation (this applies for open and closed configuration (TBC)).

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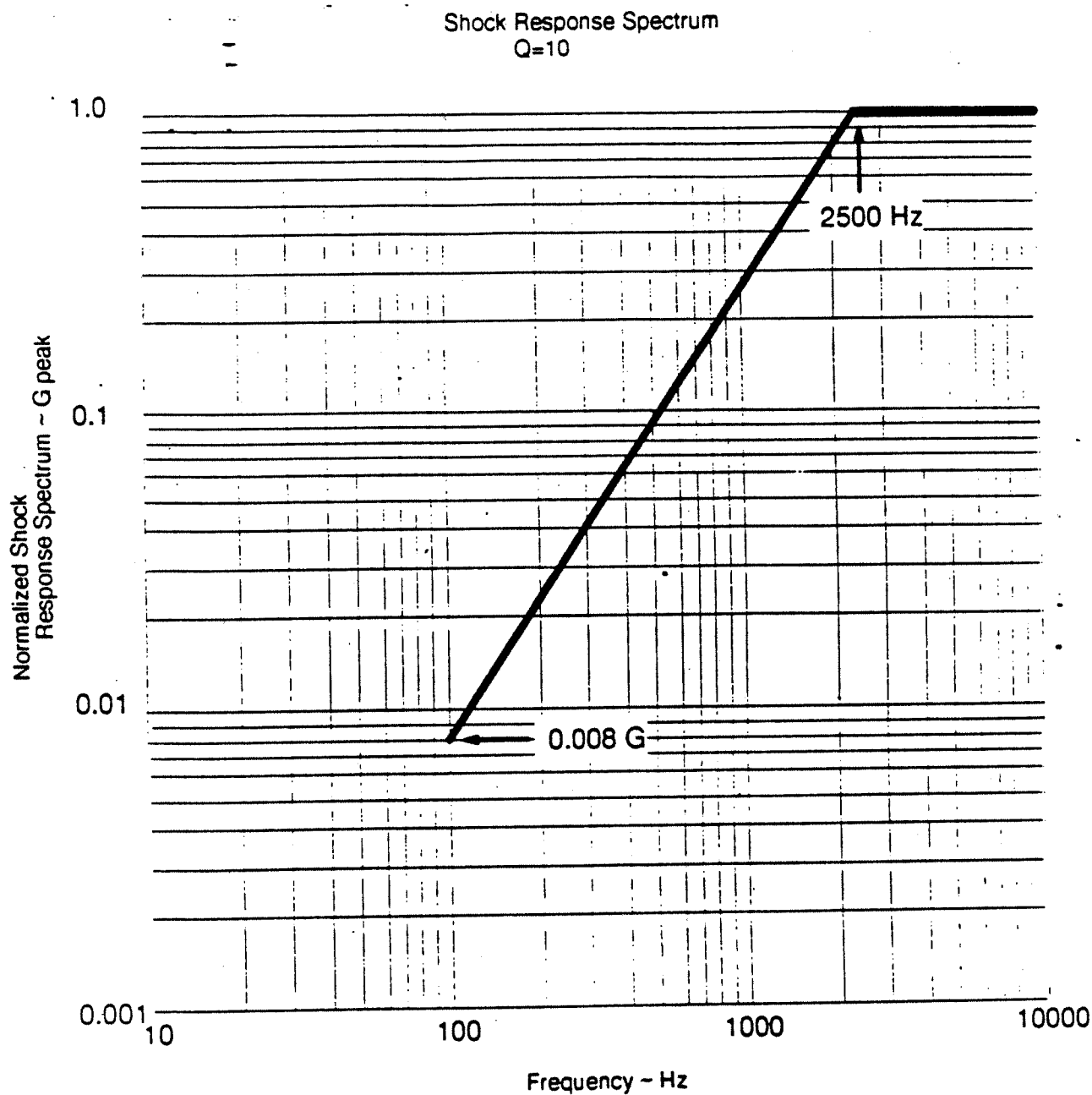


Figure 3.2.5.2.4-1 : Vibration Shock Environment

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Table 3.2.5.2.6-2 : Qualification/Protoflight Acoustic Environment

One-Third Octave Center Frequency (Hz)	Noise Level (dB) re: 20 μ N/m ²
25	-----
32	132.0
40	133.5
50	134.0
63	135.0
80	135.5
100	136.0
125	136.0
160	135.7
200	134.9
250	134.0
315	133.2
400	131.8
500	130.5
630	129.1
800	127.3
1000	125.5
1250	124.0
1600	122.0
2000	120.5
2500	119.0
3150	117.0
4000	115.5
5000	113.5
6300	111.5
8000	110.0
10000	108.0
Overall	145.7
Protoflight Duration: One Minute Qualification Duration: Two Minutes	

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Table 3.2.5.2.6-1 : Acceptance Acoustic Environment

One-Third Octave Center Frequency (Hz)	Noise Level (dB) re: 20 μN/m²
25	-----
32	129.0
40	130.5
50	131.0
63	132.0
80	132.5
100	133.0
125	133.0
160	132.7
200	131.9
250	131.0
315	130.2
400	128.8
500	127.5
630	126.1
800	124.3
1000	122.5
1250	121.0
1600	119.0
2000	117.5
2500	116.0
3150	114.0
4000	112.5
5000	110.5
6300	108.5
8000	109.7
10000	110.5
Overall	142.8
Acceptance Duration: One Minute	

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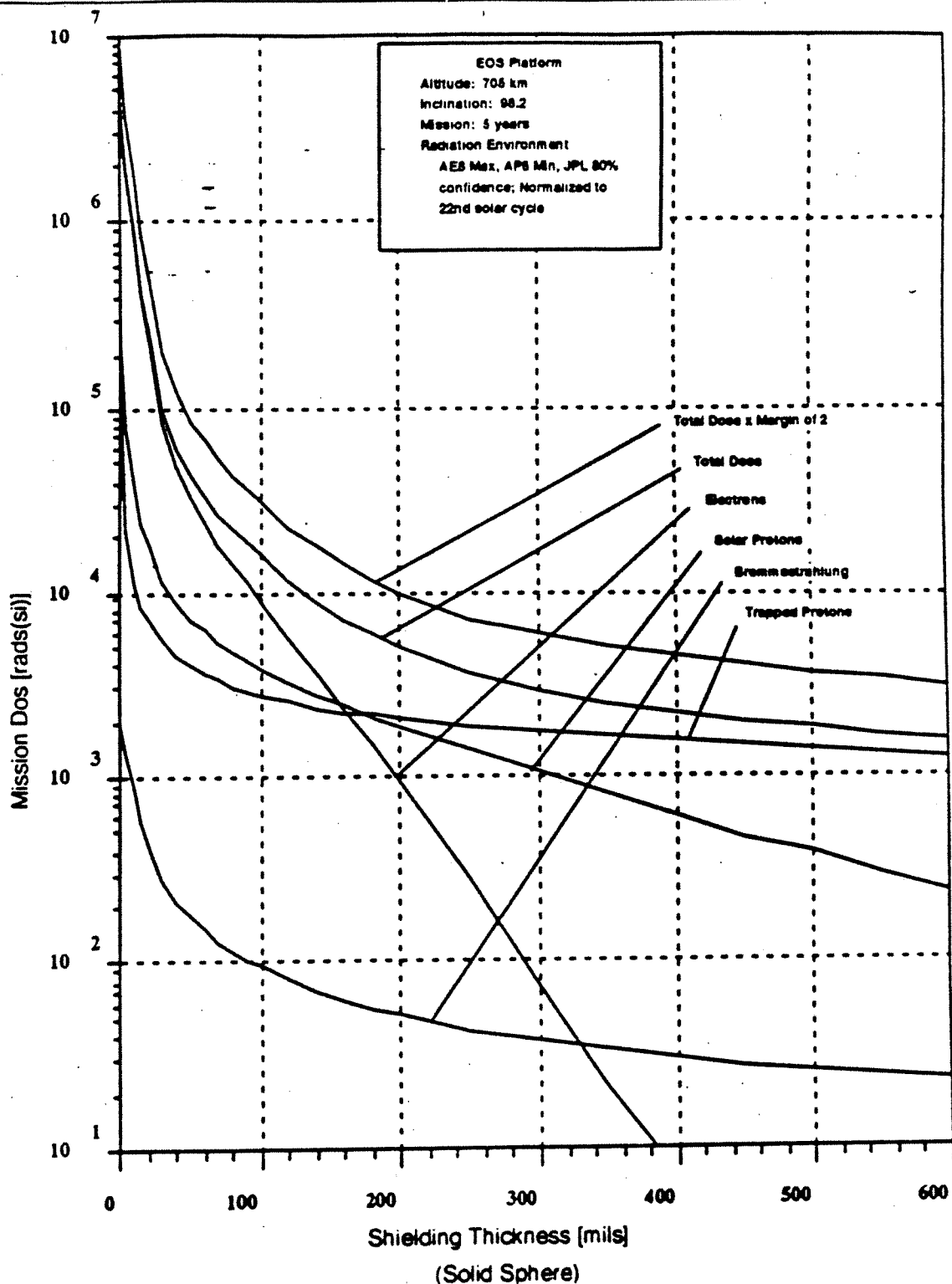


Figure 3.2.5.3-1 : Total Ionizing Dose Radiation Environment

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3.2.5.3 Radiation

3.2.5.3.1 Total Ionizing Dose Environment

The instrument shall meet performance requirements when exposed to the total dose due to trapped proton, electron and solar proton radiation environment which will be experienced by the EOS platform as shown in Figure 3.2.5.3-1. The curve is based on the integral mission duration. A design margin of 100% is also shown on the curve, this shall be used to determine predicted radiation dosage.

The worst case total dose should be calculated based on 0.65 inch baseplate effective thickness and 0.080 inch instrument cover effective thickness. If margin is not adequate then a more precise calculation should be performed.

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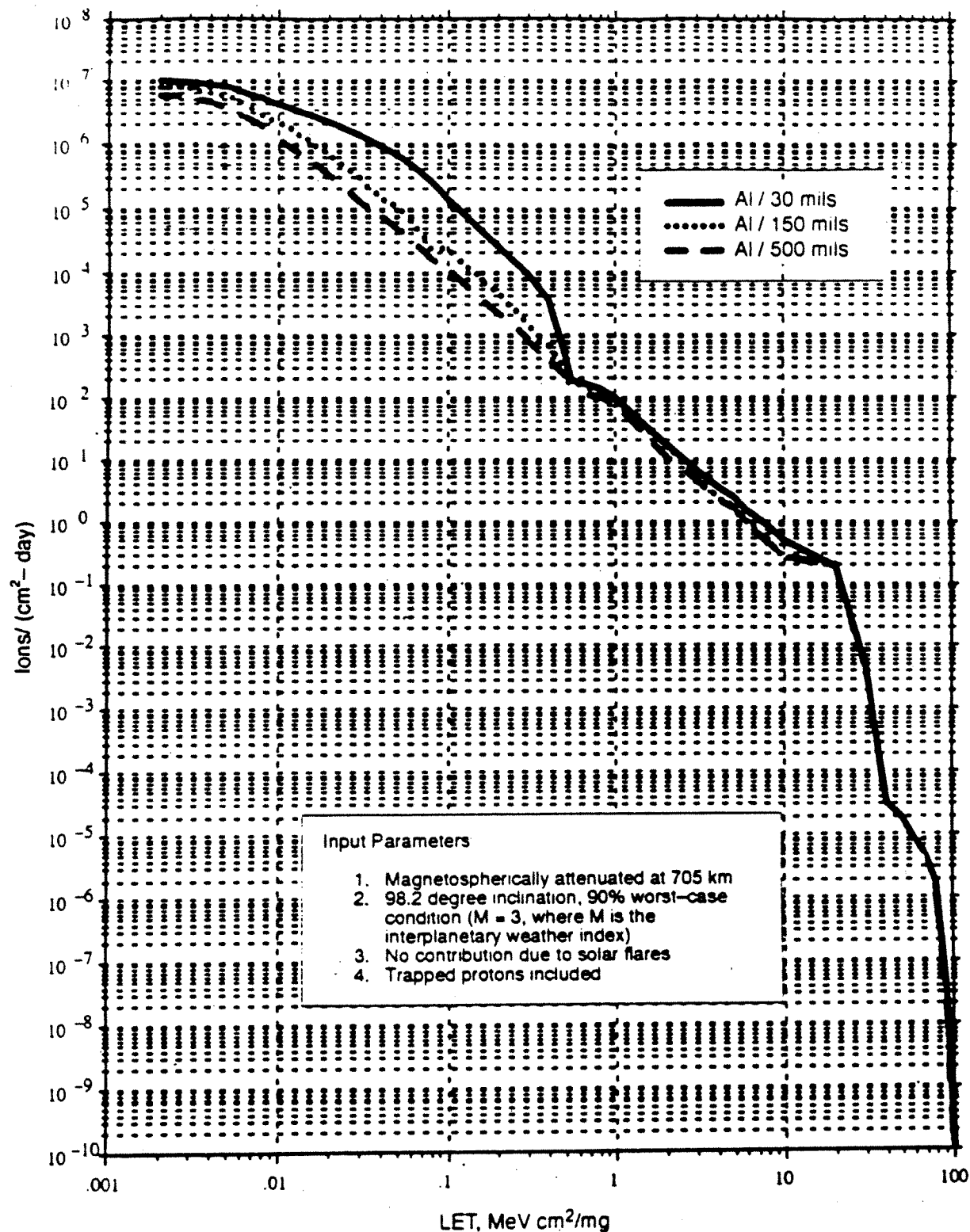


Figure 3.2.5.3-2 : Cosmic Ray Linear Energy Transfer (LET) Spectrum

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3.2.5.3.2 Single Event Upset and Latching

The cosmic ray integral linear electron transfer (LET) distribution, as shown in Figure 3.2.5.3-2, shall be used for making single event upset (SEU) and single event latchup (SEL) calculations. Under large solar flare conditions, the environment defined in AD1 10.6 shall be assumed.

Hardware shall be immune to latch-up for $LET \leq 37 \text{ MeV cm}^2/\text{mg}$. Hardware shall have an acceptable SEU rate and shall recover within TBD seconds without loss of performance.

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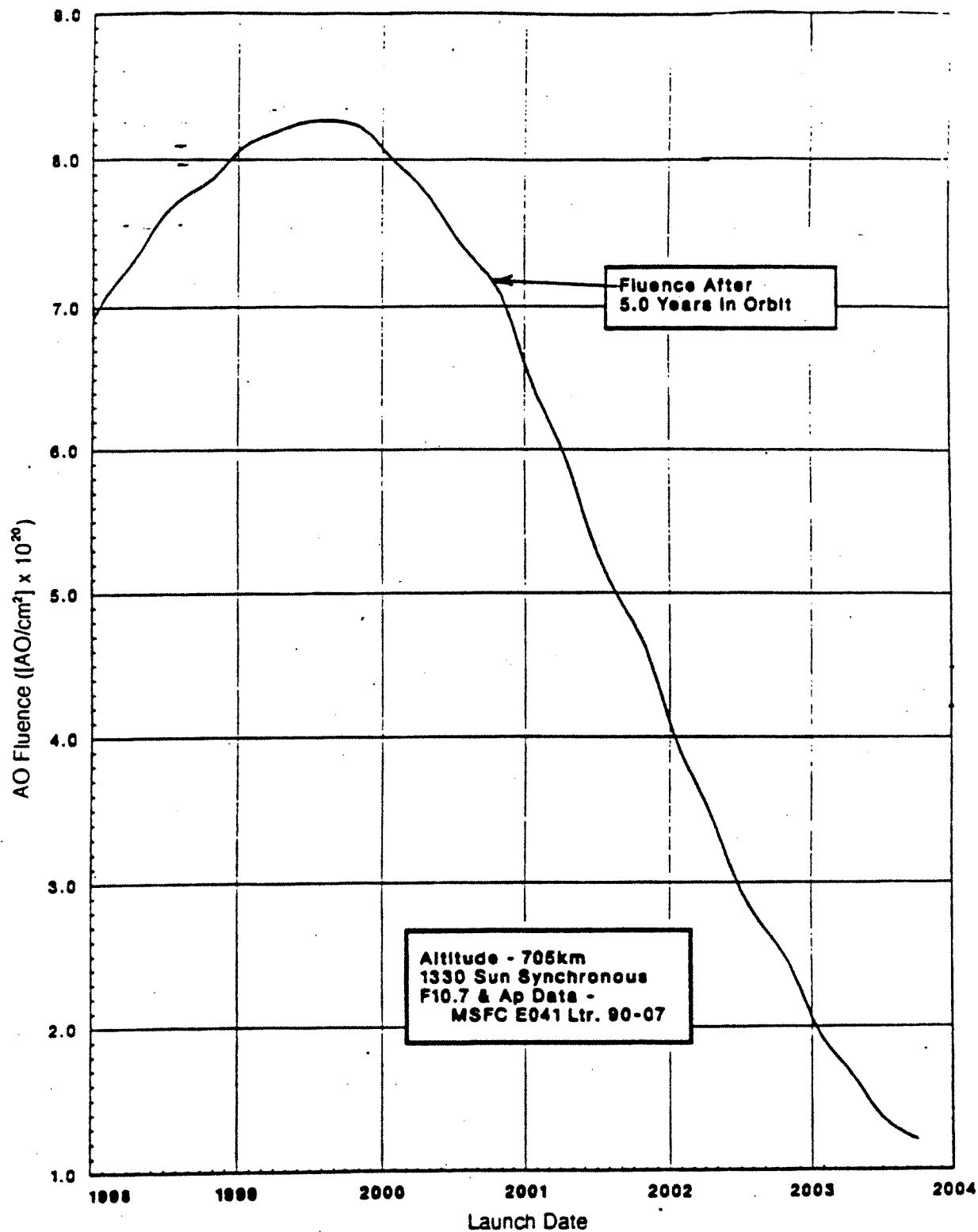


Figure 3.2.5.4-1 : Atomic Oxygen Fluences For EOS-A

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3.2.5.4

Atomic Oxygen

The instrument shall comply to the performance requirements during exposure to the atomic oxygen (AO) environment experience in a 705 km polar orbit for five years. Figure 3.2.5.4-1 shows the AO fluence for ram oriented surfaces (further analysis is required to assess AO exposure for shielded or non-ram facing surfaces). The design margin shall be TBD%.

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3.3.4 Nameplates and Product Marking

The Instrument supplier shall mark and identify all connectors and interfaces for the safe integration of the instrument onto the spacecraft. The identifying marks shall include those specified in RD1.

3.3.5 Fabrication Requirements

The instrument design shall conform to the fabrication requirements of AD5 and AD1 sections 3.14.5.6.1, 3.15.2, 3.17.1, 3.17.2, 3.10.3 and 3.10.4 unless noted in RD11.

3.3.6 Interchangeability

Within practical limits each item of equipment of the Instrument should be directly interchangeable in form, fit and function with all other equipment of the same part number and revision number. The performance characteristics shall permit equipment interchange with a minimum of adjustments and recalibrations (i.e. shimming is allowed). The equipment must be of the same qualification status and reliability to meet interchangeability requirements.

3.3.7 Safety

The Instrument shall be designed and fabricated with compatible materials in such a manner that all hazards associated with the equipment are eliminated, minimized and/or controlled as per AD5.

3.3.8 Human Performance/Human Engineering

The Instrument shall be designed to minimize demands upon operator skill, training and personnel. The instrument operation shall be through EGSE (see RD15).

3.3.9 Software Requirements

3.3.9.1 General

Software shall be developed for the Instrument to respond to discrete and serialized commands, to packetize and transmit the science, engineering and housekeeping telemetry, to control and monitor the instrument mechanisms and electrical subsystem, and to gather and process the radiometric data.

3.3.9.2 Adaptability

The software shall, at a minimum, be capable of being replaced by the upload of new software from the ground into the computer memory. This capability will permit the adjustment of the software to cope with unexpected conditions and partial failures.

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3.2.5.5 Micrometeoroid and Space Debris

The instrument will be subjected to hypervelocity impacts of meteoroids and space debris. The worst-case predicted environment is described in section 10.8 and 10.9 of AD1.

3.2.5.6 Vacuum

The Instrument shall be designed to fully operate in a vacuum of 10^{-5} torr and below.

3.2.5.7 Humidity

The Instrument shall be designed to operate in a reduced capability ground test configuration in the humidity environment of 30% to 60% relative humidity (TBC).

The instrument shall not suffer any permanent performance degradation when exposed to the ground test environment above.

3.2.6 Transportability

The Instrument shall be provided with both a suitable handling fixture and transportation container to enable its safe transport, both for delivery and for handling purposes during spacecraft integration (as defined in RD18).

3.3 Design and Construction

3.3.1 Parts, Materials and Processes

All parts, materials and processes used in the design of the Instrument shall be selected in accordance with AD5. Any non-standard parts shall be processed per AD5.

3.3.2 Electromagnetic Compatibility

The Instrument shall be designed to meet the following EMC/EMI requirements as identified in AD6, Annex 4, section 10.10. The instrument should meet the requirements defined in sections 10.10.1, 10.10.2, 10.10.3 and 10.11 of AD1.

3.3.3 Electrostatic Discharge Control

The Instrument shall follow the guidelines for prevention of electrostatic discharge given in AD5.

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3.5.4 Ground Support Equipment

The MOPITT instrument will require specialized ground support equipment (GSE). This is categorized as electrical (EGSE), mechanical (MGSE) or optical (OGSE).

3.5.4.1 EGSE

The MOPITT instrument requires a bench checkout unit (BCU) which shall meet the requirements of AD4 section; 7.7.1.1, 7.7.1.2, 7.7.1.3, 7.7.1.4, 7.7.1.5, 7.7.1.6, unless noted in RD11. Detailed requirements are shown in RD15.

3.5.4.2 MGSE

The MOPITT instrument requires MGSE including the following; lift sling, handling fixtures, shipping container, vibration jig, test coldplate and vacuum pumps.

The lift sling and handling fixtures shall meet requirements in AD1 section 3.16, and AD4 section 7.7.2, unless noted in RD11.

3.5.4.3 OGSE

The MOPITT OGSE includes various IR sources (at ICF) and additional alignment verification equipment.

3.6 Personnel and Training

3.6.1 Personnel

See RD 15.

3.6.2 Training

See RD 15.

3.7 Major Component Characteristics

The following Section describes the required characteristics of the major components of the MOPITT Instrument as defined in Section 3.1.1.2.

In addition to meeting the general requirements in section 3 and the specific requirements for each major component which are documented in the following sections, the following requirements shall apply;

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3.3.9.3 Development Languages

The software shall use high-level languages wherever possible. Commercially available, mature products, with sustaining support services shall be used. Software support shall be for TBD years.

3.3.9.4 Application Process Identification

The instrument is allocated the 64 science-data Application Process Identification (APID) numbers which lie within the decimal-equivalent range of 192-255, inclusive (as per section 3.1.3 of AD2).

3.3.10 Contamination Control

The level of acceptable contamination shall be determined by analysis following section 9 of the PAR (AD3).

The instrument shall meet the cross-contamination and outgassing requirements specified in section 9.3 of AD3. The details of how this requirement and sections 8.1, 8.2, 8.3 and 8.4 of AD1 shall be met are documented in RD7, unless noted in RD11.

3.3.11 Leakage

All hermetically sealed cavities of the gas modulating cells shall have a leakage rate of less than 2×10^{-10} scc/sec (cc at STP per second).

3.4 Documentation

Documentation shall be as tasked in the contract statement of work and prepared and delivered in accordance with AD6.

3.5 Logistics

3.5.1 Maintenance

The Instrument and subsystem construction shall be such that these can be maintained within the requirements of Section 3.2.4 of the specification.

3.5.2 Supply

Not Applicable.

3.5.3 Facilities and Facility Equipment

Facility and facility equipment requirements as defined in RD5 shall apply.

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- The interface details and characteristics are defined in RD3.
- Each major component shall comply with the EMC requirements and guidelines defined in RD8.
- Figure 3.7-1 shows the instrument internal redundancy. The following table defines the redundancy requirements for each major component or module.

Table 3.7-1 : Subsystem and Module Redundancy Requirements

Subsystem/Module	Redundancy Requirements	Comment
Optical Subsystem	no requirement	
Detection Arrays	no requirement	
PSM & PDM & PCDM	Completely Redundant	launch off-inhibit in PSM not redundants
ICM	Completely Redundant	hot redundant cross-strapped 1553 B transceivers, additional redundant ROM banks on each processor
SPM	no requirement	
TCMM	Completely Redundant	cross-strapped to non-redundant heaters and sensors
Calibration Sources	Partially Redundant	heater and PRTs are redundant
Cooler Subsystem	no requirement	
Structural/Thermal Subsystem	Partially Redundant	redundant actuators
PMC Assemblies	no requirement	
LMC Assemblies	no requirement	
PLDM and SCDM	partially redundant	redundant ICM and PDM interfaces

For all non-redundant circuits the design shall minimize the possibility of a single failure causing a significant loss in functionality.

The detailed requirements for each major component are documented in their respective specifications.

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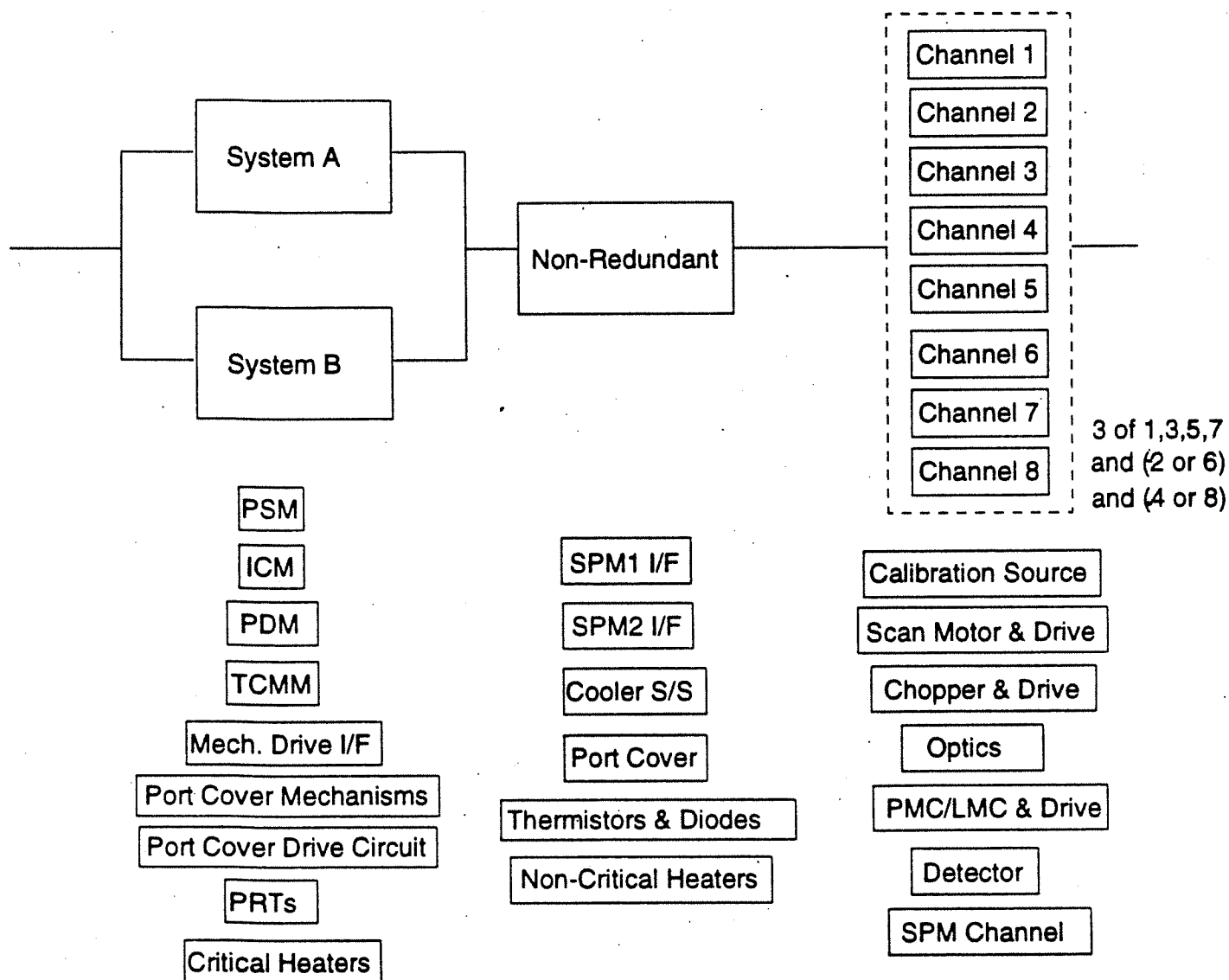


Figure 3.7-1: Internal Redundancy Diagram

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3.7.1 Optical Subsystem

The optical subsystem shall have the characteristics defined in this section.

3.7.1.1 Definition

The optical subsystem consists of the physical elements listed in Table 3.1.1.2-2.

The two halves of the optical subsystem are identical except for the following;

- the chassis' are mirror images of each other about the X-axis
- the scan mirror positions are offset in height between the two tables
- the chopper and gas cell frequencies of operation are slightly different

3.7.1.2 Functional Requirements

- The optical subsystem functional diagram is shown in Figure 3.7.1.2-1

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mm	millimeter
MOPITT	Measurements Of Pollution In The Troposphere
MSB	Most Significant Bit
N	Newton
NASA	National Aeronautical and Space Administration
N/A	Not Applicable
OGSE	Optical Ground Support Equipment
PAIP	Performance Assurance Implementation Plan
PAR	Performance Assurance Requirements
PCA	Port Cover Assembly
PCDM	Port Cover Drive Module
PDM	Power Distribution Module
PDR	Preliminary Design Review
PLDM	PMC/LMC Drive Module
PMC	Pressure Modulator Cell
PMR	Pressure Modulator Radiometer
PRT	Platinum Resistance Thermometer
P _s	Probability of Success
PSM	Power Supply Module
SCC	Stirling Cycle Cooler
SCDM	Scanner Chopper Drive Module
STP	Standard Pressure
SPM	Signal Processing Module
TBD	To Be Determined
TBC	To Be Confirmed
TBR	To Be Resolved
TBS	To Be Supplied
TCMM	Thermal Control and Monitoring Module
TML	Total Mass Loss
UIID	Unique Instrument Interface Specification
V	Voltage
Vdc	Voltage Direct Current
W	Watt

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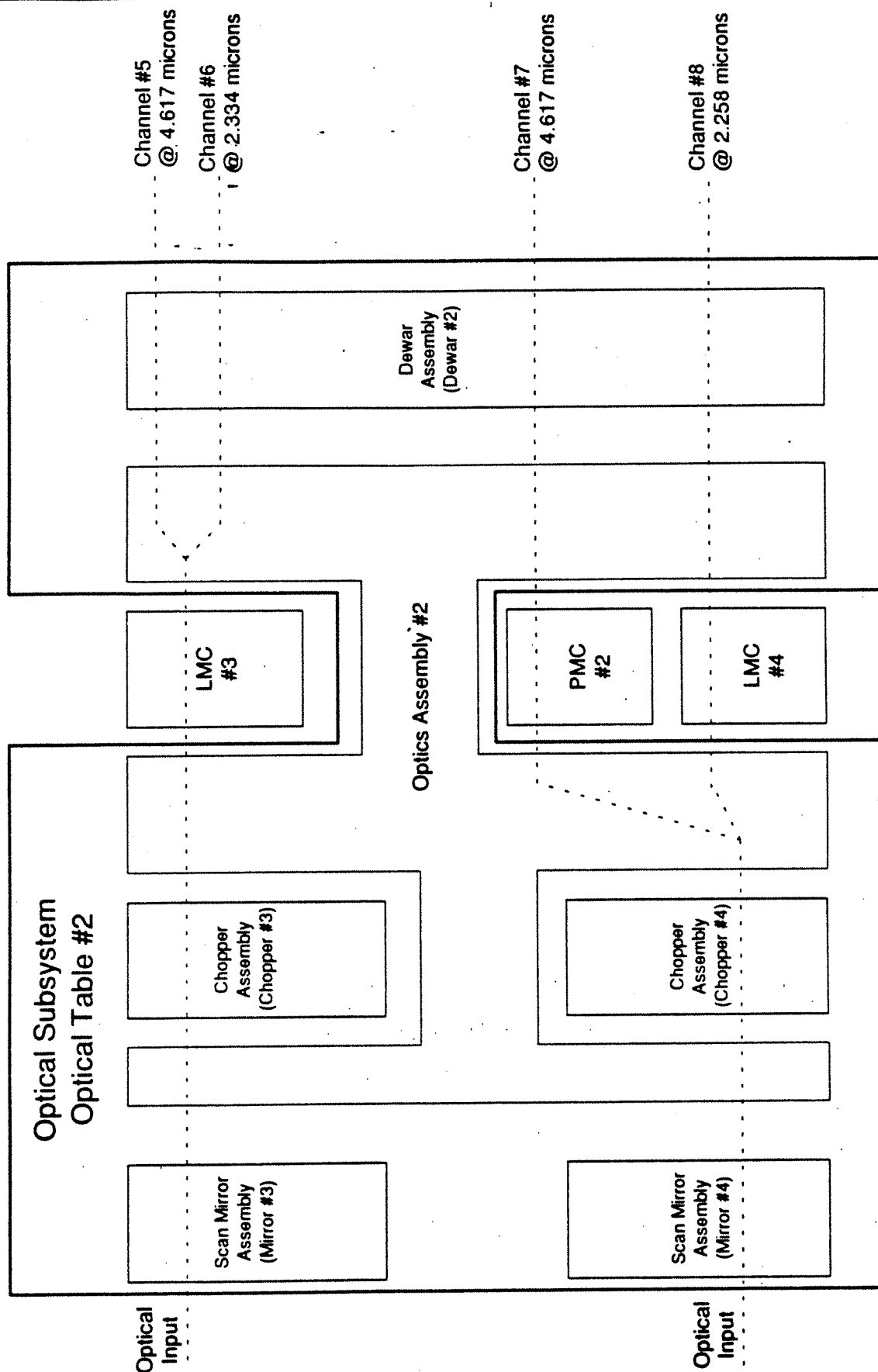


Figure 3.7.1.2-1: Optical Subsystem Functional Diagram Cont'd

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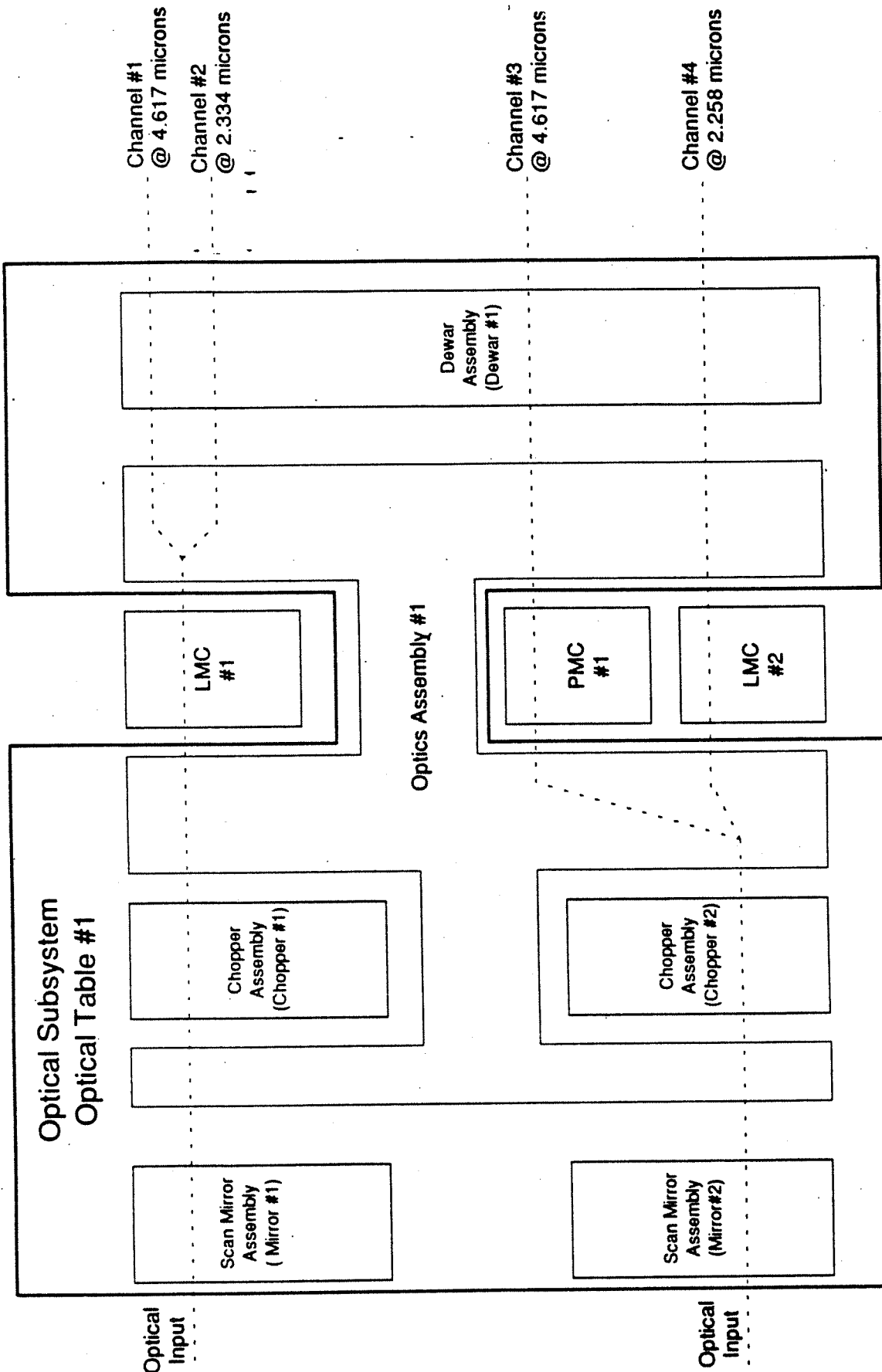


Figure 3.7.1.2-1: Optical Subsystem Functional Diagram

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- The temperature requirements for the optical subsystem are defined in Table 3.7.1-1
- The optical subsystem shall meet the chopper performance requirements in Section 3.2.1.1.5.
- The chopper modulation jitter shall be less than 1% of a cycle per cycle.
- Chopper 1 and 3 shall have 18 cycles per rotation, chopper 2 and 4 shall have 21 cycles per rotation.
- The mark space ratio shall be 55 open: 45 closed.

Table 3.7.1-1 Optical Subsystem Operating, Non-operating and Start-up Temperatures

Item	Acceptance [°C]	Qualification [°C]	Non-operating [°C]	Start-up [°C]
Optical S/S	10 to 40	5 to 45	-30 to 60	N/A
Scan Mirror Assembly	10 to 40	5 to 45	-30 to 60	0
Chopper Assembly	10 to 40	5 to 45	-30 to 60	0
DCO	-183 to -173 (90 K to 100 K)	N/A	-196 to 60 (77 K to 333 K)	(77 K to 333 K)
Cold Filter	-178 to -158 (95 K to 115 K)	N/A	-196 to 60 (77 K to 333 K)	N/A

- The optical subsystem shall meet the pointing and co-location requirements defined in Tables 3.2.1.1-3 and 3.2.1.1-5 respectively.

3.7.1.4 Interface Requirements

The optical subsystem electrical and optical interfaces are shown in Figure 3.7.1.4-2. The details of these interfaces are defined in RD3.

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- The dewar shall be vented during instrument vacuum tests and during the mission.
- The optical subsystem shall be configured to provide eight separate images, one per channel. The channels shall be numbered and configured to comply with Table 3.1.1.1-1.
- The optical subsystem shall meet the functional requirements in Sections 3.1.1.1.1.
- The optical subsystem shall include the necessary temperature monitors and heaters as defined in Tables 3.1.1.1-4 and 3.1.1.1-5 respectively.
- The optical subsystem shall include the stray light control design features defined in section 3.2.1.1.1.7.
- The optical subsystem shall be designed to minimize disassembly and re-test activities if an LMC or PMC is installed or removed.
- The optical tables shall be designed to be removable and re-installable with a minimal disassembly and re-test activities.

3.7.1.3 Performance Requirements

The detailed requirements are defined in EQS/MOP/113361/100, however, the main requirements are summarized here.

- The optical subsystem shall meet the filter profile performance requirements in Section 3.2.1.1.1.1.
- The optical subsystem shall meet the FOV performance requirements in Section 3.2.1.1.1.2.
- The optical subsystem shall meet the scanning rate performance requirements in Section 3.2.1.1.1.4, this requires that all four mirrors shall be moveable within a time envelope such that the combined step and settle time for the scan mirror assembly shall be less than 0.049 seconds for a 1.8 degree step or a 3.6 degree step.
- The optical subsystem image quality, transmission and polarization shall have the performance requirements defined in Section 3.2.1.1.1.6.
- The mass of the optical subsystem shall not be greater than the values shown in Table 3.2.2.3-1.
- The power consumption of the optical subsystem shall not be greater than the values shown in Table 3.2.1.4-2.

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3.7.2 Detection Arrays

3.7.2.1 Definition

A detection array is defined as consisting of a detector package, associated pre-amplifiers and associated wiring/connectors. The detector package, in turn, is comprised of a kovar housing body and detector circuit with any relevant internal interconnections and package feedthroughs.

Eight detection arrays in all are present within the MOPITT instrument, which are separated into two identical groups of four (each associated with a dewar assembly).

Within each group of four detection arrays there are three types of detection arrays, which differ in performance requirements. These types have been defined and identified by the individual detector designators -1, -2 and -3.

A single specification document is used to define the requirements for all of the detection arrays within the MOPITT instrument (see Table 3.1.1.2-2).

3.7.2.2 Functional Requirements

The function of the detection arrays is to convert infrared radiation obtained from the optical subsystem to analog signals, provide pre-amplification, and monitor its temperature.

The detection array package will be welded to the cold optics assembly to form the detector cold optics (DCO). The DCO will be a hermetically sealed unit. The DCO will be mechanically clamped around its perimeter using thermal contraction forces.

The detection arrays shall meet the following functional requirements;

- contain four detection elements in line along the velocity vector at the optics input
- contain temperature monitors as defined in Table 3.1.1.1-4
- contain dedicated pre-amplifiers for each detection element

3.7.2.3 Performance Requirements

The detailed requirements for the detection arrays are defined in EQS/MOP/113365/500 however the major requirements are summarized here.

- The mass of the detection arrays shall not be greater than 12 grams each and not greater than 74.5 grams for each DCO.

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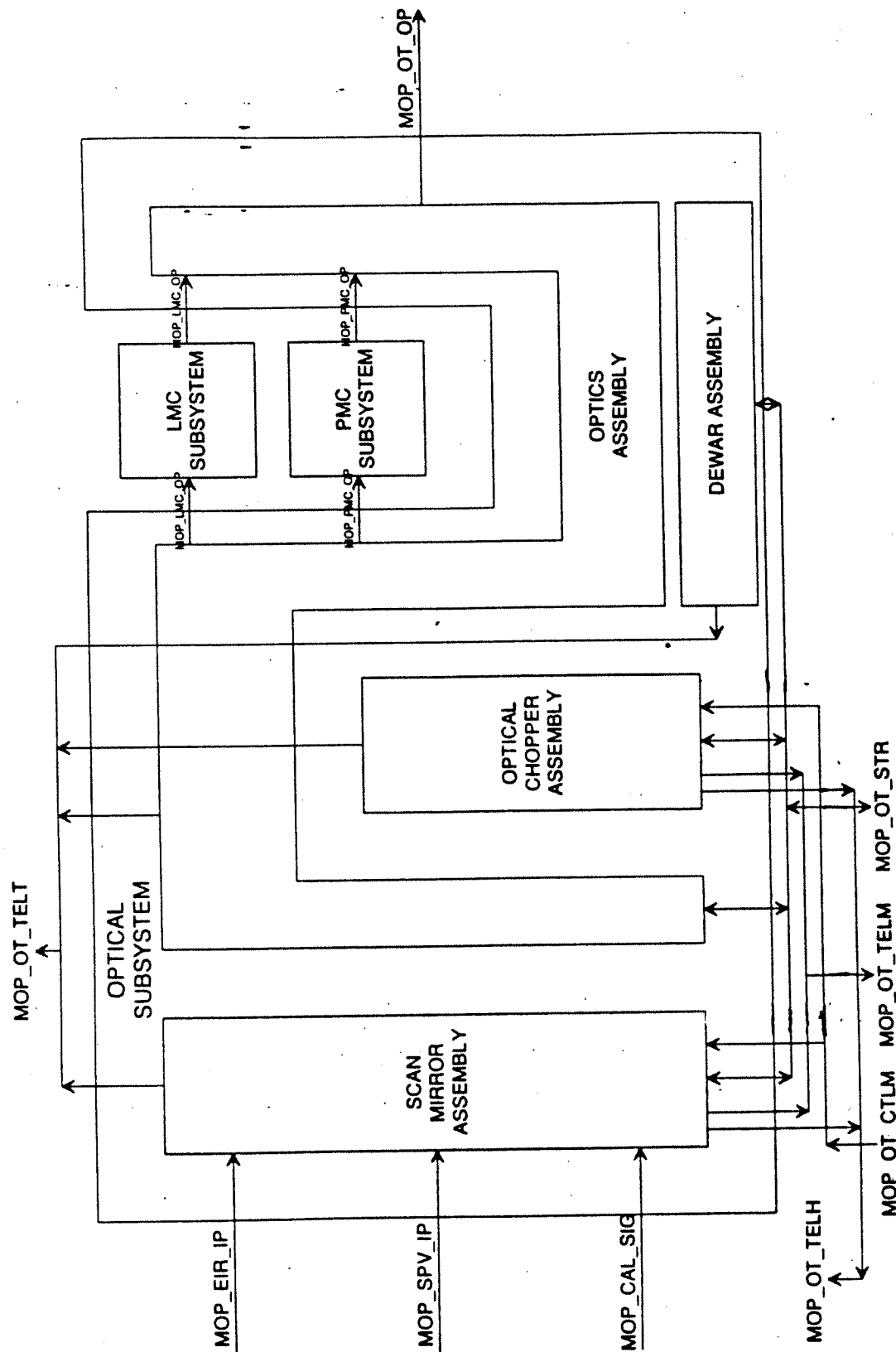


Figure 3.7.1.4-1: Optical Subsystem Interface Diagram

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Table 3.7.2.3-3 : Detection Array Performance Requirements (for 100 K $\pm$ 1 K at 600 Hz).

Parameter	Unit	Detector Type		
		-1	-2	-3
Source Passband λ	μm	4.562-4.672	2.323-2.344	2.222-2.291
Detector Passband λ	μm	4.5 - 4.7	2.3 - 2.4	2.2 - 2.35
Input Flux Density - nominal - maximum	$\text{ph/cm}^2\cdot\text{s}$	2.60×10^{14} 1.04×10^{15}	1.21×10^{13} 4.76×10^{13}	4.68×10^{13} 2.00×10^{14}
D*	$\text{cm}\cdot\text{rHz/W}$	8.91×10^{11}	1.74×10^{12}	9.79×10^{11}
NEP	W/rHz	1.00×10^{-13}	6.37×10^{-14}	9.87×10^{-14}
Responsivity	V/W	8.91×10^6	1.50×10^7	1.45×10^7
Maximum Power Per Package	W	0.045	0.045	0.045
Responsivity (DCO)	V/W	5.86×10^8	7.1×10^8	7.5×10^8

3.7.2.4 Interface Requirements

Figure 3.7.2.2-1 identifies the instrument internal interfaces which have been defined for each detection array.

The following detection array interface requirements have been identified

Optical Science Data (MOP OT SCI) Input Interface :

The detection array detector package shall be mechanically positioned (as defined by distance from and orientation to Optical subsystem focusing lens) in such a way as to ensure

- the desired flux density (see Table 3.7.2.3-1) is presented to each detection array diode element.
- the detection array detector elements shall be in line along the velocity vector at the optics input.

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The temperature requirements for the detection arrays are defined in Table 3.7.1-1 (DCO).

The detection array performance requirements are defined in Tables 3.7.2.3-1, 3.7.2.3-2 and 3.7.2.3-3.

Table 3.7.2.3-1 : Detection Array Characteristics

Characteristic	Value
Detector Type	Indium antimonide (InSb)
Element Size (Active Area)	0.9 mm × 0.9 mm ± 10 µm each dimension
Gap between elements	≤ 0.035 mm
Quantum Efficiency	≥ 80%
Field of view	35° per half angle
Crosstalk (electrical and optical)	≤ 0.5% at 600 Hz
Misalignment (to array center point)	≤ 13 µm

Table 3.7.2.3-2 : Preamplifier Requirement

No.	Characteristic	Value
a	Feedback Resistance	$R_f \pm 0.5\%$, where $R_f = 3 \text{ M}\Omega$ for -1 detector $R_f = 10 \text{ M}\Omega$ for -2 and -3 detectors
b	3 dB Bandwidth	≥ 10 kHz and ≤ 15 kHz
c	Output Impedance	TBD
d	Output Signal Linearity	≤ 0.001% over 1 V interval

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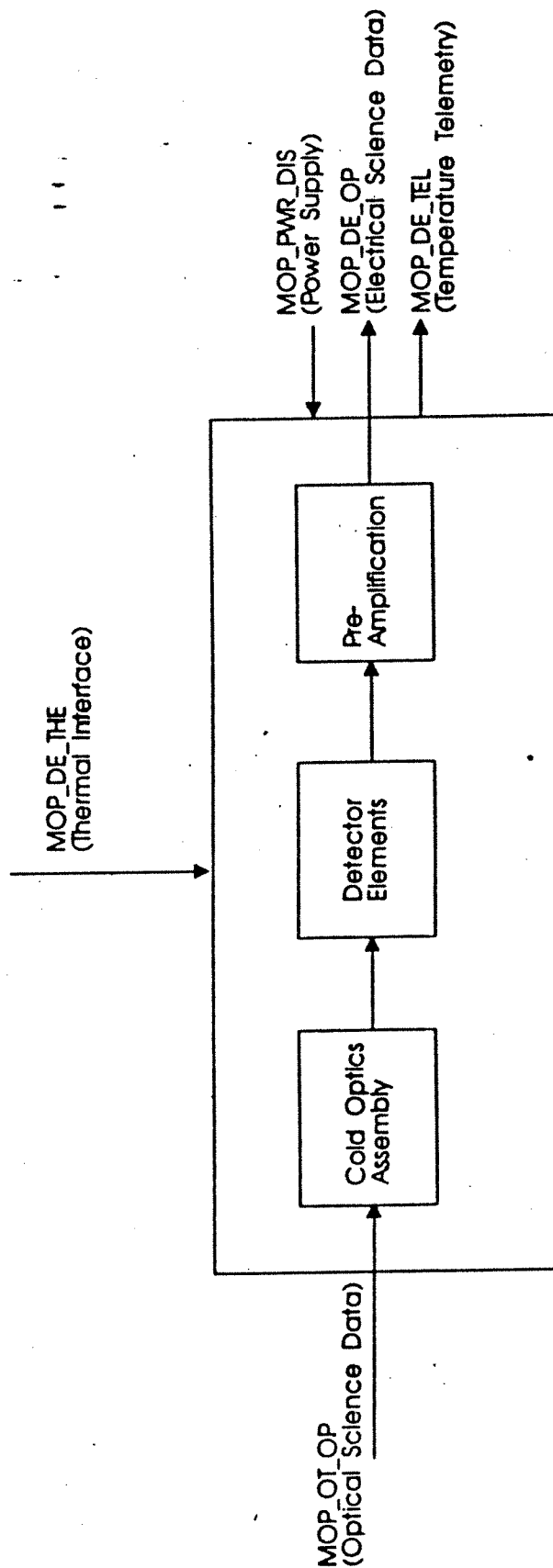


Figure 3.7.2.2-1: Detection Array Interfaces

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Electrical Science Data (MOP EL SCI) Output Interface :

Both electrical and mechanical (e.g. physical wiring) interfacing shall be identified with regard to the detection array ambient pre-amplifiers output lines to ensure appropriate

- mechanical interface
- voltage signal levels
- output impedances

in order to enable optimum interfacing to the Electrical Subsystem input electronics.

Thermal Sensing (MOP DE THE) Output Interface :

Both electrical and mechanical (e.g. physical wiring) interfacing shall be identified with regard to the detection array detector package output lines to ensure appropriate

- mechanical interface
- voltage signal levels
- output impedances
- diode bias current

in order to enable optimum interfacing to the SPM input telemetry electronics.

Power Distribution (MOP PWR DIS) Input Interface :

Both electrical and mechanical (e.g. physical wiring) interfacing shall be identified with regard to the detection array power lines to ensure appropriate

- mechanical interface
- power consumption budgeting
- sizing of interface wires

in order to enable optimum interfacing to the SPM power distribution electronics.

Regulation and filtering of power lines associated with detection arrays shall be provided within the SPM.

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- The SPM shall have programmable blanking and integration periods for each of the choppers and LMCs.
- Each of the blanking and integration periods shall be programmable between zero and the maximum duration of one state of the associated chopper or LMC.

Table 3.7.3.2-1 : SPM Science Data Characteristics

Parameter	Requirement
Number of Pixels (sub-channels)	16
Full Scale Input Voltage	-0.35 to -3.50 dependant on channel I/F requirements
A/D Quantization	16 bits
A/D Settling Time to 1×10^{-4} (TBC)	< 25 μ s (TBC)
A/D Configuration	Delta-Sigma
Science Data Sum Quantization	24 bits
Size	3X12.2X6.5 in.

- The SPM shall exhibit sufficient stiffness that its fundamental fixed base frequency is no less than 150 Hz.
- The mass of the SPM shall not be greater than the values shown in Table 3.2.2.3-1.
- The power consumption of the SPM shall not be greater than the values shown in Table 3.2.1.4-2.
- The temperature requirements for the SPM are defined in Table 3.7.3.2-2

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3.7.3 Electronics Modules

3.7.3.1 Definition

The Electronics Modules perform all instrument control functions, accept commands from the spacecraft and provide telemetry to the spacecraft for downlink and provides electrical power conversion for the instruments. The Electronic Modules consists of the following:

- Signal Processing Module (SPM x 2)
- Instrument Controller Module (ICM)
- Port Cover Drive Module (PCDM)
- Thermal Control and Monitoring Module (TCMM)
- Power Supply Module (PSM)
- Scan/Chopper Drive Module (SCDM)
- Power Distribution Module (PDM)
- PMC/LMC Drive Module (PLDM)

The instrument internal interface designations for these modules are documented in RD3.

3.7.3.2 Functional and Performance Requirements

The Electronics Modules functional and performance requirements are defined against each of the modules.

3.7.3.2.1 Signal Processing Module Requirements

- During scanning mode the SPM shall process the detection array outputs and produce the summed totals for each sector and chopper state, consistent with the requirements in section 3.1.1.1.2.
- The SPM shall provide raw digital samples when it is in burst mode operation.
- The SPM noise contribution shall be less than $89 \text{ nV } \sqrt{\text{Hz}}$ at 600 Hz.
- The SPM characteristics are defined in Table 3.7.3.2-1
- The SPM shall supply a reference clock to the timing control circuitry of the ICM.
- The SPM shall provide regulated and filtered power rails for the detectors with a noise level no greater than $300 \text{ nV}/\sqrt{\text{Hz}}$ at 600 Hz. These power rails shall be capable of being turned off by command.

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Table 3.7.3.2-2 SPM Operating, Non-operating and Start-up Temperatures

Average Interface Temperatures (°C)	Min	Max
Non-operating (Survival mode)	-30	60
Start-up	-25	N/A
Acceptance	+10	+45
Qualification	+5	+50

3.7.3.2.2 Port Cover Drive Module Requirements

The PCDM shall control and monitor the Port Cover Assembly deployment. The PCDM shall operate from survival rails and maintain the PCA temperatures within acceptable limits. The PCDM shall interface to the ICM, PCA and spacecraft (3.1.2.1.4).

The mass of the PCDM shall not be greater than the values shown in Table 3.2.2.3-1.

The PCDM shall exhibit sufficient stiffness that its fundamental frequency is no less than 150 Hz.

The power consumption of the PCDM shall not be greater than the values in Table 3.2.1.4-2.

The temperature requirements for the PCDM are defined in Table 3.7.3.2-3.

Table 3.7.3.2-3 PCDM Temperature Requirements

Average Interface Temperatures [°C]	Min.	Max.
Non-operating (Survival)	-30	60
Acceptance	-25	55
Qualification	-30	60

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3.7.3.2.3 Thermal Control and Monitoring Module Requirements

The TCMM shall monitor and control instrument temperatures as defined in Table 3.1.1.1-4 and 3.1.1.1-5. The TCMM shall provide analog to digital and digital to analog conversion respectively as part of its monitor and control functionality.

The TCMM shall also monitor the LMC pressures as per section 3.2.1.1.2.
The mass of the TCMM shall not be greater than the values shown in Table 3.2.2.3-1.

The TCMM shall exhibit sufficient stiffness that its fundamental fixed base frequency is no less than 150 Hz.

The power consumption of the TCMM shall not be greater than the values shown in Table 3.2.1.4-2.

The temperature requirements for the TCMM are defined in Table 3.7.3.2-4.

Table 3.7.3.2-4 TCMM Operating, Non-operating and Start-up Temperatures

Average Interface Temperatures (°C)	Min.	Max.
Non-operating (Survival mode)	-30	+60
Start-up	-25	N/A
Acceptance	+10	+45
Qualification	+5	+50

3.7.3.2.4 Power Supply Module Requirements

The PSM requirements are defined in EQS/MOP/113363/301 and are summarized here;

- convert the 120 V dc input to the necessary voltage rails as summarized in Table 3.7.3.2-5.
- configure itself to provide launch rails only, survival rails only, operational rails, or operational and survival rails.
- have an overall conversion efficiency of 77% (TBC) minimum at the end of life.
- radiate any heat generated to cold space via an ambient temperature radiator.

The PSM forms a major part of MOPITT's external electrical interface to the spacecraft. As such the PSM shall support the requirements of section 3.1.2.1.3, 3.1.2.1.8, 3.1.2.1.9 (partial), and 3.1.2.1.10 (partial)

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Table 3.7.3.2-5: PSM Output Power Rails (for one side)

SUPPLY VOLTAGE	NO. OF OUTPUT RAILS	USED BY
+28 V	2	SCDM
+6.5 V	1	SPM 1
+16.35 V	1	
-16.35 V	1	
+6.5 V	1	SPM 2
+16.35 V	1	
-16.35 V	1	
+14 V, +13.5 V	2	TCMM
-14 V, -13.5 V	2	
+13.7 V	3	SCDM, PLDM, PCDM
-13.7 V	3	
+5.1 V	3	ICM, SCDM, PLDM, PCDM
+28 V	1	Cooler subsystem
+28V (survival)	1	PCDM & Survival Heaters

A subset of the output rails from the PSM are the 4 launch rails (+28V, +13.7V and +5.1V to chopper drive circuitry of the SCDM and the LMC drive circuitry of the PLDM) and these rails can be left on when the rest of the rails are turned off

The mass of the PSM shall not be greater than the values shown in Table 3.2.2.3-1.

The PSM shall exhibit sufficient stiffness that its fundamental fixed base frequency is no less than 150 Hz.

The temperature requirements for the PSM are defined in Table 3.7.3.2-6.

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Table 3.7.3.2-7 ICM Operating, Non-operating and Start-up Temperatures

Average Temperatures (°C)	Min.	Max
Non-operating (Survival mode)	-30	+60
Start-up	-25	N/A
Acceptance	+10	+45
Qualification	+5	+50

The ICM shall provide the instrument external interfaces defined in section 3.1.2.1.4 (partial), 3.1.2.1.5, 3.1.2.1.6, 3.1.2.1.7, and 3.1.2.3.

3.7.3.2.6 Power Distribution Module Requirements

The PDM shall distribute the voltage rails (supplied from the PSM) to the required pin contacts to feed each module. The PDM shall provide fuses to circuits so that the single point failures cannot propagate through the instrument.

The mass of the PDM shall not be greater than the values shown in Table 3.2.2.3-1.

The PDM shall exhibit sufficient stiffness that its fundamental frequency is no less than 150 Hz.

The power consumption of the PDM shall not be greater than the values in Table 3.2.1.4-2.

The temperature requirements for the PDM are defined in Table 3.7.3.2-8.

Table 3.7.3.2-8: PDM Temperature Requirements

Average Temperatures (°C)	Min.	Max
Non-operating (Survival mode)	-30	+60
Acceptance	-25	55
Qualification	-30	60

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3.7.3.2.7 PMC/LMC Drive Module Requirements

The PLDM shall provide drive signals to each PMC mechanism and LMC mechanism. The PLDM shall also detect the position feedback signal from each PMC and each LMC. The PLDM shall lock the mechanism drive rate to an external reference timing signal. The PLDM interface to the ICM shall allow command and telemetry of this information.

The mass of the PLDM shall not be greater than the values shown in Table 3.2.2.3-1. The PLDM shall be capable of operating the PMC in open or closed loop. During closed loop the resonant frequency shall be determined with a resolution and repeatability of 0.018 Hz (TBC).

The PLDM shall exhibit sufficient stiffness that its fundamental frequency is no less than 150 Hz.

The power consumption of the PLDM shall not be greater than the values in Table 3.2.1.4-2. The temperature requirements for the PLDM are defined in Table 3.7.3.2-9.

Table 3.7.3.2-9: PLDM Temperature Requirements

Average Temperatures (°C)	Min.	Max
Non-operating (Survival mode)	-30	+60
Start-up	-25	N/A
Acceptance	+10	+45
Qualification	+5	+50

3.7.3.2.8 Scan/Chopper Drive Module Requirements

The SCDM shall provide drive signals and detect position feedback for each scan motor and chopper motor. The SCDM shall lock the drive rate to an external reference timing signal. The SCDM interface to the ICM shall allow command and telemetry of this information.

The mass of the SCDM shall not be greater than the values shown in Table 3.2.2.3-1.

The SCDM shall exhibit sufficient stiffness that its fundamental frequency is no less than 150 Hz.

The power consumption of the SCDM shall not be greater than the values in Table 3.2.1.4-2.

The temperature requirements for the SCDM are defined in Table 3.7.3.2-10.

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Table 3.7.3.2-10: SCDM Temperature Requirements

Average Temperatures (°C)	Min.	Max
Non-operating (Survival mode)	-30	+60
Start-up	-25	N/A
Acceptance	+10	+45
Qualification	+5	+50

3.7.4 Calibration Sources

The Calibration sources shall have the characteristics defined in this section.

3.7.4.1 Definition

The calibration sources consists of four blackbody sources (numbered one through four corresponding to the scan mirror numbering) and connectors/harnessing which interfaces directly to the TCMM.

3.7.4.2 Functional Requirements

The calibration source functional diagram is shown in Figure 3.7.4.2-1.

The calibration sources shall provide radiometric targets during ground tests and flight. The temperature of the blackbody shall be programmable. The target temperature shall be monitored accurately and precisely. The temperature distributions must be satisfy the calibration analysis requirements.

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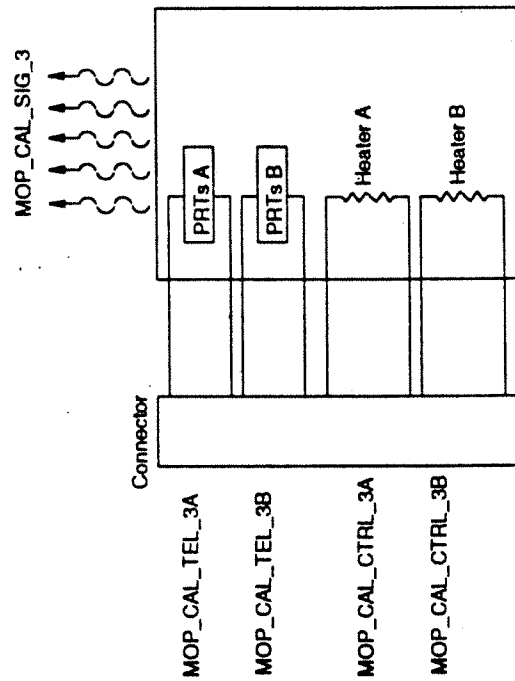
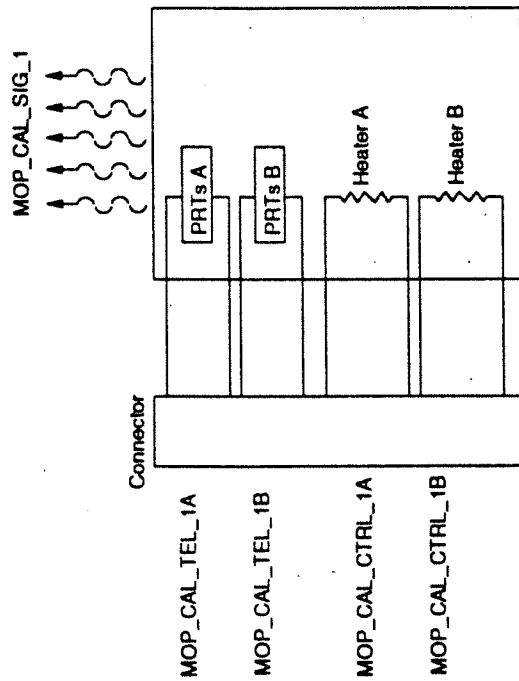
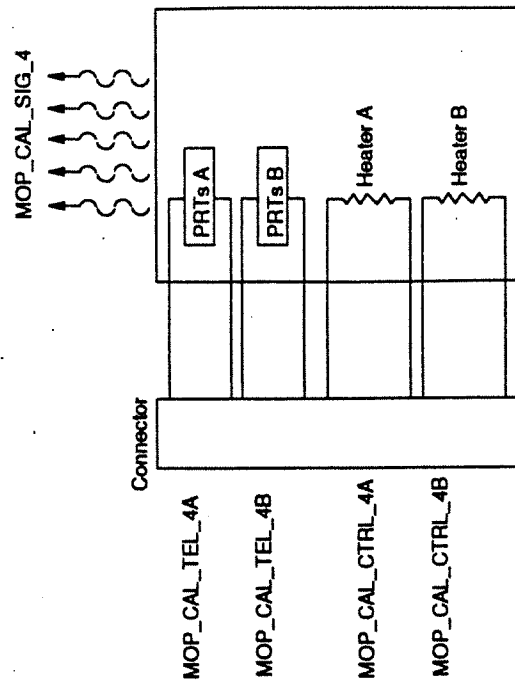
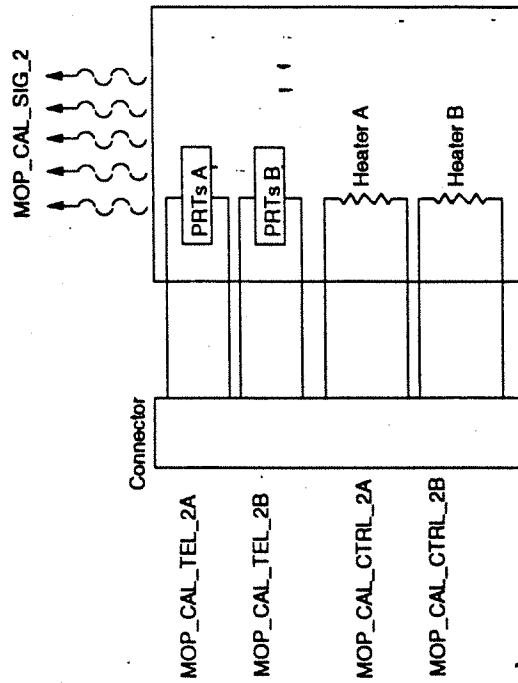


Figure 3.7.4.2-1: Calibration Subsystem Functional Diagram

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3.7.4.3 Performance Requirements

The Calibration subsystem performance characteristics are defined for each of the two calibration modes; 300-K Calibration Mode and 500 K Calibration Mode.

The calibration source heaters and temperature sensors shall be implemented as redundant isolated sets (set A and set B). Calibration source heaters and temperature sensors shall be provided per the requirements of Table 3.1.1.1-5 and 3.1.1.1-4 respectively.

The calibration source radiance shall be known with an accuracy as defined in section 3.2.1.1.4.

The mass of the calibration sources shall not be greater than the values shown in Table 3.2.2.3-1.

The power consumption of the calibration sources shall not be greater than the values shown in Table 3.2.1.4-2.

The temperature requirements for the calibration sources are defined in Table 3.7.4.3.-1

Table 3.7.4.3-1 Calibration Sources Operating, Non-operating and Start-up Temperatures

Average Interface Temperatures (°C)	Min.	Max
Non-operating (Survival mode)	-30	+60
Start-up	-25	N/A
Operating	+10	+40
Qualification	+5	+45

3.7.4.4 Interface Requirements

The calibration subsystem interface details are defined in RD3.

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3.7.5 Cooler Subsystem

3.7.5.1 Definition

The Cooler Subsystem consists of 2 Stirling Cycle Coolers (SCCs), supporting bracketry, the Cooler Drive Electronics (CDE) and harnessing from the CDE and the SCCs. Each cooler consists of 1 compressor unit and 1 displacer unit connected together via a transfer tube.

3.7.5.2 Functional Requirements

The Cooler Subsystem, which is shown in Figure 3.7.5-1, has the following prime functions within MOPITT:

- cool the IR detectors and cold optics
- minimize the vibration transferred to the instrument and hence the spacecraft.

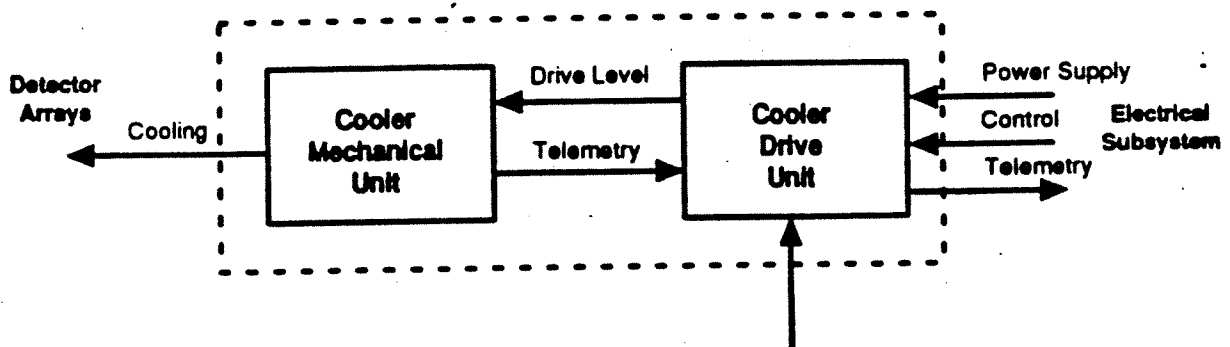


Figure 3.7.5-1: Cooler Subsystem Functional Block Diagram

The cooler subsystem shall perform these functions as required by the various operating states defined in Section 3.2.1.1 for the total life of the mission.

The subsystem shall monitor the temperature of the detector assembly and use this as a feedback signal to control that temperature. The subsystem shall also monitor the unbalanced accelerations of the coolers and use this as a feedback signal to control these accelerations.

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3.7.5.3 Performance Requirements

This section discusses the performance characteristics for the cooler subsystem. The two prime performance characteristics of the subsystem are the cooling performance and the vibration compensation.

The subsystem shall cool each of the detectors to a temperature not greater than 100 K (TBC) with a heat load of less than 0.85 W per cold finger (TBC).

The vibration compensation shall be such that forces and moments transferred to the instrument must be less than TBD N (TBD lb) and TBD N·m (TBD lb·in). The residual vibration shall meet the requirements in section 3.7.6.2.2.1 and 3.7.6.2.3.1 of AD1.

The mass of the cooler subsystem shall not be greater than the values shown in Table 3.2.2.3-1.

The power consumption of the Cooler Subsystem shall not be greater than the values shown in Table 3.2.1.4-2.

The temperature requirements for the Cooler Subsystem are defined in Table 3.7.5.3.-1

Table 3.7.5.3-1 Cooler Subsystem Operating, Non-operating and Start-up Temperatures

Average Interface Temperatures (°C)	Min.	Max.
Non-operating (Survival Mode)	-30	+60
Start-up (Compressors and Displacers)	-10	N/A
Acceptance (Compressors and Displacers)	+10	+40
Acceptance (CDE) (TBC)	+15	+40
Qualification (Compressors and Displacers)	+5	+45
Qualification (CDE)	TBD	TBD

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3.7.5.4 Interface Requirements

The Cooler Subsystem interfaces are shown in Figure 3.7.5-2 and will include the following;

- interface to detectors - to provide cooling to detector arrays
- interface to detector dewar structure to provide a vacuum seal for ambient pressure testing.
- interface to detector dewar structure for feedback temperature sensor electrical feedthrough.
- interface to baseplate - bracketry and CDE to baseplate mechanical and thermal interface.
- electrical interface - the cooler drive electronics interface with the instrument power supply and the instrument computer.

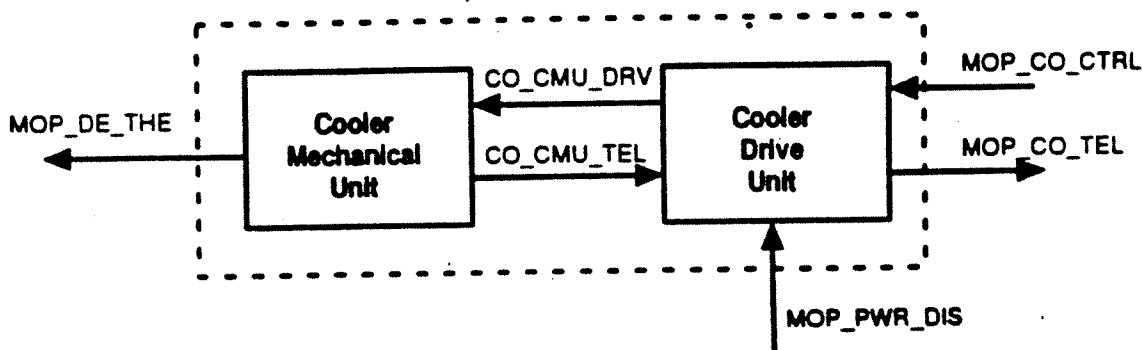


Figure 3.7.5-2: Cooling Subsystem Interface Block Diagram

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3.7.6 Structural/Thermal Subsystem

3.7.6.1 Definition

The structural/thermal subsystem consists of the instrument baseplate, cover, port covers, optical baffles, actuators for port covers, MLI and the wire harness. An interface block diagram of the subsystem is shown in Figure 3.7.6-1.

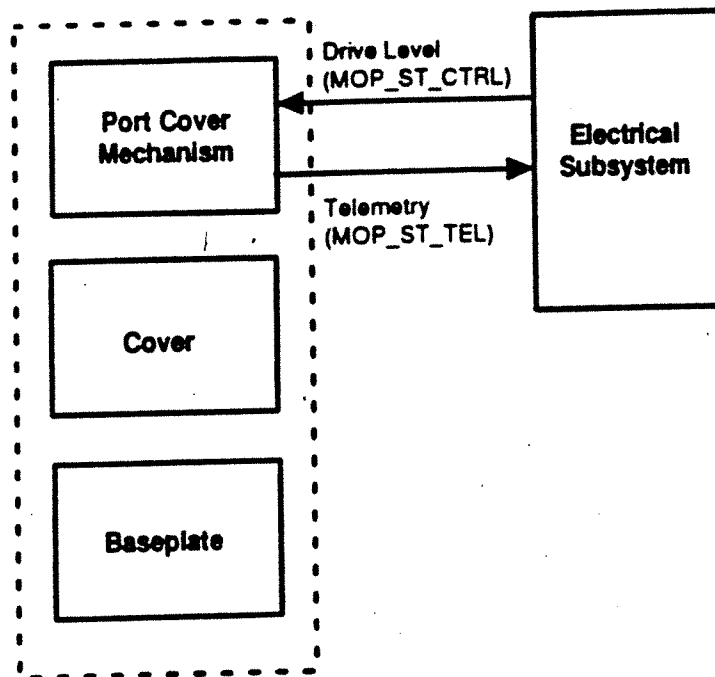


Figure 3.7.6-1 Structural/Thermal Subsystem Interface Block Diagram

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3.7.6.2

Functional Requirements

The Structural/Thermal subsystem performs the following functions:

- provides structural support for all instrument devices.
- provide thermal insulation around the instrument cover and underneath the instrument, including the underside of the coldplate.
- provide contamination, EMI/EMC and radiation shielding for the instrument.
- transport all device dissipations (except PSM) to the spacecraft-supplied coldplate, while minimizing the temperature gradient from the devices to the coldplate.
- open the earth and space view ports when commanded to do so by the drive electronics.
- provide straylight rejection from external sources for the optical subsystem.
- allow the instrument alignment to be measured and adjusted during instrument integration and during integration to the platform.
- minimize effects of distortions due to spacecraft motion or instrument thermal stresses on the pointing of the instrument.
- provide mounting for electrical interfaces and cutouts for ground support equipment (TBC).
- protect the instrument from micrometeoroids and atomic oxygen.
- provide venting
- provide electrical signal/power distribution within the instrument
- functional requirements defined in section 3.1.1.1.8, 3.1.1.1.9, 3.1.1.1.10, 3.1.1.1.12 and 3.1.1.1.13.
- provide an alignment cube for referencing the optical FOV.

3.7.6.3

Performance Requirements

The Structural/Thermal Subsystem has the following performance requirements:

- The instrument structure shall have a minimum structural frequency of 35 Hz (with a design goal of 70 Hz).
- The instrument structure shall support the other instrument subsystems such that the instrument alignment and performance are within specification in Table 3.2.1.1-3 and 3.2.1.1-4 after being subjected to the launch loads of Section 3.2.6.
- The Structural/Thermal Subsystem shall provide a maximum baseplate temperature of 30°C (TBC) when bolted to the spacecraft-supplied coldplate.

The mass of the Structural/Thermal Subsystem shall not be greater than the values shown in Table 3.2.2.3-1.

The power consumption of the Structural/Thermal Subsystem shall not be greater than the values shown in Table 3.2.1.4-2.

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Table 3.2.5.2-1 shows the interface temperature requirements for the Structural/Thermal Subsystem at the coldplate surface.

3.7.6.4 Interface Requirements

The Structural/Thermal Subsystem has the following interfaces:

- the optical subsystem electronics modules, calibration sources and cooler subsystem will have direct thermal and mechanical interfaces with the instrument baseplate and cover.
- the harness will interface with the various modules as per RD3.
- the Structural/Thermal Interface will provide the mechanical and thermal interfaces to the EOS platform structure and coldplate and shall comply with sections 3.1.2.1.10 and 3.1.2.1.11.
- Electrical connectors to the EOS platform shall be supported at the defined location.
- the optical fields of view for the instrument shall be provided by the port opening.
- the Structural/Thermal Subsystem will interface with ground support equipment as required to perform the various instrument tests, including handling and shipping fixtures.
- the PCA interface to the PDM is defined in RD3.

3.7.7 PMC Assemblies

3.7.7.1 Definition

The PMC assemblies includes two PMC units each with their own sieve and mounting bracket.

The PMCs and sieves are provided GFE as described in section 3.1.4.

3.7.7.2 Functional Requirements

The PMC shall operate at or very near its resonance during its normal operation in a synchronized manner with the chopper. The PMC and drive shall be capable of performing a resonance determination during flight to calibrate the PMC average gas pressure. The PMC nominal functional characteristics are defined in Table 3.1.1.1-1.

3.7.7.3 Performance Requirements

The gas correlation cells shall meet the performance requirements defined in Section 3.2.1.1.2. The PMCs shall have an optical balance that is known to ± 30 ppm (TBC) over the mission.

The PMCs shall not have any mechanical resonances within TBD Hz of the operating frequency.

The mass of the PMC assemblies shall not be greater than the values shown in Table 3.2.2.3-1.

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The power consumption of the PMC assemblies shall not be greater than the values shown in Table 3.2.1.4-2.

The temperature requirements for the PMC are defined in Table 3.7.7.3-1

Table 3.7.7.3-1 PMC Operating, and Non-operating Temperatures

Average Interface Temperatures (°C)	Min.	Max
Non-operating (Survival Mode)	-30	+60
Acceptance	+10	+40
Qualification	+5	+45

3.7.7.4 Interface Requirements

The PMC electrical interfaces are defined in section 3.1.2.2 and in RD3.

3.7.8 LMC Assemblies

3.7.8.1 Definition

There are two LMC assemblies in the instrument, each is comprised of a bracket, CO LMC, a CH₄ LMC, a CO sieve, 2 tubing assemblies, 2 pressure sensors and one wiring harness.

3.7.8.2 Functional Requirements

The LMC shall be synchronized to the chopper mechanism through the ICM timing control. The rotation rate shall be adjustable via the ICM timing control over the range defined in section 3.2.1.1.2.

The LMC nominal functional requirements including the following:

- optical modulation at gas resonance lines
- pressure sensing
- temperature sensing
- gas ballasting

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3.7.8.3 Performance Requirements

The gas correlation cells shall meet the performance requirements defined in Section 3.2.1.1.2. The LMCs shall have an optical balance that is known to ± 30 ppm over the mission.

The LMCs shall not have any mechanical resonances within 5 Hz (TBC) of the operating frequency.

The mass of the LMC assemblies shall not be greater than the values shown in Table 3.2.2.3-1.

The power consumption of the LMC assemblies shall not be greater than the values shown in Table 3.2.1.4-2.

The temperature requirements for the LMC are defined in Table 3.7.8.3-1

Phase lag between bow ties shall be less than 3°EOL.

Table 3.7.8.3-1 LMC and Drive Operating and Non-operating Temperatures

Average Interface Temperatures (°C)	Min	Max
Non-operating (Survival Mode)	-30	+60
Acceptance	+10	+40
Qualification	+5	+45

3.7.8.4 Interface Requirements

The LMC electrical interfaces are defined in section 3.1.2.2 and RD3.

3.7.9 MOPITT Software

The MOPITT Instrument software shall run on its own microprocessor consisting of a processor, PROM and RAM memory, and systems specific I/O. The ICM software shall meet the following requirements.

The ICM shall monitor the vital health of the MOPITT Instrument.

The ICM shall allow for the uploading of new software from the ground.

The ICM software shall be developed using a high-level language wherever possible.

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The ICM software shall support instrument control (TBC), diagnosis, health and status monitoring via the external test port.

The ICM shall telemeter the voltage and current monitors in 3.1.1.1.15 every TBD seconds.

The ICM shall report any detected momentary error (SEU).

The ICM software shall control and monitor the MOPITT Instrument devices, gather and process the radiometric data, and format and send the Telemetry to the spacecraft.

Unless noted in RD11, the ICM software shall comply with AD4 sections; 7.2.3, 7.2.4.5, 7.2.6, 7.4.5.1, 7.4.5.2, 7.4.5.3, 7.4.5.4, 7.5.1, 7.5.3.1, 7.5.3.2, 7.6.1.1, 7.6.1.2, 7.6.1.3, 7.8.1 and 7.8.2.

Unless noted in RD11, the ICM software shall comply with all applicable subsections of AD1 section 6 and 7.

3.8

Precedence

This specification is subject to the requirements of the EOS General Instrument Interface Specification (AD1), the Performance Assurance Performance Requirements for EOS General Instruments (AD3), the MOPITT Mission Description Document (AD4), and the Unique Instrument Interface Document (AD2) at the revisions noted in section 2 as defined in AD6. Conflicts between these documents shall be resolved by MOPITT Science Team, Canadian Space Agency and NASA/EOS Team.

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4.0 QUALITY ASSURANCE PROVISIONS

4.1 General

The Instrument shall be designed, manufactured, tested, stored and handled according to the PA requirements defined in AD5. The Instrument shall be fully assembled, tested and verified as defined in the Instrument Verification Plan (RD5) and Instrument Integration Plan (RD10).

4.2 Quality Conformance Inspections

The requirements of this specification shall, as a minimum, be verified according to the verification matrix contained in Section 4.4 of this specification, and as the PA requirements (AD5).

4.2.1 Testing

Testing is performing quantitative measurements of specified parameters under specified conditions.

4.2.2 Inspection

Inspection is performed by visual checks, dimensional checks and/or measurements to verify such requirements as construction, workmanship, physical condition and dimensions. Inspection is performed by review of documentation and/or of the product.

4.2.3 Analysis

Analysis is the use of recognized analytical techniques, including the use of computer models, to predict equipment performance or to interpret test data to prove equipment performance.

4.2.4 Demonstration

Demonstration is the performance of the actual function of the product, where visual observation is the primary means of verification. Demonstration is used when quantitative assurance is not required for verification.

4.3 Verification of Performance and Design Requirements

4.3.1 Qualification Tests

The EQM Instrument shall be subjected to qualification testing as defined in the approved EQM plan.

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4.3.2 Flight Model Acceptance Tests

The FM Instrument shall be subjected to the acceptance test requirements defined in the approved acceptance test plan.

4.3.3 Flight Model Spacecraft Integration Tests

Spacecraft integration testing will be subject to the requirements defined in AD1 sections 3.14.5.9.1, 4.6.1.3.

4.4 **Verification Matrix**

The verification matrix, Table 4.4-1, is included in this specification as an input to the production of the Instrument verification plan (RD5) and the integration plan (RD10). The details given in the matrix, represent the minimum verification requirements.

Detailed test plans and procedures for each model of the instrument must be prepared and submitted to CSA for approval as per AD6.

The MOPITT instrument will be verified by COM DEV at the nominal operating frequencies only. The instrument is designed to be operated at other frequencies in contingency situations, but not during normal operations.

The redundant system (System B) will also be tested as part of COM DEV's instrument verification.

The following terminology is used in Table 4.4-1;

ANS: Analysis; ISP: Inspection; TST:Test; DEM: Demonstration;

INS: Instrument; M C: Major Component; ASY: Assembly; UNT: Unit;

QUA: Qualification; ACT: Acceptance

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Table 4.4-1 Instrument Verification Matrix

Ref. Para.	Description	Method				Level of Assembly			
		A N S	I S P	T S T	D E M	I N S	M C	A S Y	U N T
3.1	Instrument Definition								
3.1.1	Instrument Diagrams and Functional Description		x			x			
3.1.1.1	Detailed Functional Requirements		x			x			
3.1.1.1.1	Optical Channel Configuration		x			x			
3.1.1.1.2	Signal and Data Processing		x			x			
3.1.1.1.3	Instrument Control and Timing		x			x			
3.1.1.1.4	Telemetry Interface		x			x			
3.1.1.1.5	Instrument Computer	x				x			
3.1.1.1.6	Thermal Control and Monitoring				x	x			
3.1.1.1.7	Voltage Conversion and Isolation		x					x	
3.1.1.1.8	Internal Signal Routing		x			x			
3.1.1.1.9	Structural Support		x			x			
3.1.1.1.10	Contamination Sealing		x		x	x			
3.1.1.1.11	Cryogenic Cooling				x	x			
3.1.1.1.12	Heat Path to Cooling Loop	x				x			
3.1.1.1.13	Thermal and Radiation Shielding		x			x			
3.1.1.1.14	Power Distribution and Fusing		x			x			
3.1.1.1.15	Voltage and Current Monitoring		x			x			
3.1.1.2	Configuration Description		x				x		
3.1.2	Interface Definition								
3.1.2.1	External Interfaces								
3.1.2.1.1	Earth Infrared Input (MOP_EIR_IP)		x		x				
3.1.2.1.2	Space View Input (MOP_SPV_IP)		x		x				

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Ref. Para.	Description	Method				Level of Assembly			
		A N S	I S P	T S T	D E M	I N S	M C	A S Y	U N T
3.1.2.1.3	Power and Supply Discrete Command and Telemetry (MOP_PSM_DCT)		x		x		x		
3.1.2.1.4	Instrument Discrete Command and Telemetry (MOP_INS_DCT)			x		x			
3.1.2.1.5	Time Mark and Frequency Bus (MOP_SC_TMF)			x		x		x	
3.1.2.1.6	Command and Telemetry Bus (MOP_SC_BCT)			x		x		x	
3.1.2.1.7	Low-Rate Science Output Data (MOP_SC_OP)			x		x		x	
3.1.2.1.8	Power Interface (MOP_SC_PWR)			x		x		x	
3.1.2.1.9	Ground Interface (MOP_SC_GND)			x		x			
3.1.2.1.10	External Thermal Interface (MOP_SC_THE)			x		x			
3.1.2.1.11	External Structural Interface (MOP_SC_STR)			x		x			
3.1.2.2	Major Component Interfaces		x	x	x	x	x	x	
3.1.2.3	Diagnostic Interfaces				x	x		x	
3.1.3	Major Component List								
3.1.4	Government Furnished Property List								
3.1.5	Government Loaned Property List								
3.2	Characteristics								
3.2.1	Instrument Performance Requirements								
3.2.1.1	Science Performance Requirements								
3.2.1.1.1	Optical Performance								
3.2.1.1.1.1	Filter Profiles	x		x					x
3.2.1.1.1.2	Field of View (FOV)	x		x		x	x		
3.2.1.1.1.3	Boresight Alignment	x		x		x	x		
3.2.1.1.1.4	Scanning Implementation			x	x	x		x	

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Ref. Para.	Description	Method				Level of Assembly			
		A N S	I S P	T S T	D E M	I N S	M C	A S Y	U N T
3.2.1.1.1-5	Chopper Performance Requirements	x			x	x		x	
3.2.1.1.1.6	Imaging Performance	x		x		x	x	x	x
3.2.1.1.1.7	Stray Light	x				x			
3.2.1.1.2	Gas Correlation Performance	x		x		x			
3.2.1.1.3	Radiometric Performance	x		x		x			x
3.2.1.1.4	Calibration Performance	x		x		x	x		
3.2.1.2	Instrument Operating Modes								
3.2.1.2.1	Instrument Operating Modes Descriptions				x	x			
3.2.1.2.2	S/C Mode Relationship to Instrument Mode		x			x			
3.2.1.3	C & T Lists		x			x			
3.2.1.4	Power Requirement								
3.2.1.4.1	Primary Power Allocation	x		x		x	x	x	
3.2.1.4.2	Power Characteristics	x		x		x	x		
3.2.1.4.3	Power Budget	x		x				x	
3.2.1.5	Data Rate	x		x		x			
3.2.2	Instrument Physical Characteristics								
3.2.2.1	Physical Description		x			x			
3.2.2.2	Mass	x		x		x	x	x	x
3.2.2.3	Mass Budget	x		x			x	x	x
3.2.2.4	Size		x			x			
3.2.2.5	Center of Mass	x				x	x	x	
3.2.2.6	Moments and Products of Inertia	x				x			
3.2.2.7	Venting	x				x			
3.2.2.8	Mechanical Requirements								
3.2.2.8.1	Stiffness	x		x		x	x	x	x
3.2.2.8.2	Strength								
3.2.2.8.2.1	Safety Margins	x				x	x	x	x

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Ref. Para.	Description	Method				Level of Assembly			
		A N S	I S P	T S T	D E M	I N S	M C	A S Y	U N T
3.2.2.8.2.2-	Fatigue	x				x	x	x	x
3.2.2.9	Unbalanced Forces, Torques and Angular Momentum	x		x			x	x	
3.2.2.10	Pressurized Systems	x						x	
3.2.2.11	Torque Margin	x		x				x	x
3.2.3	Design Life & Reliability								
3.2.3.1	Design Life	x				x	x	x	x
3.2.3.2	Reliability	x				x	x	x	x
3.2.4	Maintainability				x	x			
3.2.5	Environmental Conditions								
3.2.5.1	Temperature	x		x		x	x	x	
3.2.5.2	Vibration and Shock	x		x		x			
3.2.5.2.1	Launch Limit Loads	x		x		x			
3.2.5.2.2	Random Vibration	x		x		x			
3.2.5.2.3	Sine Vibration	x		x		x			
3.2.5.2.4	Shock	x		x		x			
3.2.5.2.5	Launch Pressure Profile	x		x		x		x	
3.2.5.2.6	Acoustics	x				x			
3.2.5.3	Radiation								
3.2.5.3.1	Total Ionizing Dose Environment	x		x					x
3.2.5.3.2	Single Event Upset and Latching	x							x
3.2.5.4	Atomic Oxygen	x				x	x		
3.2.5.5	Micrometeoroid and Space Debris	x				x			
3.2.5.6	Vacuum	x		x		x			
3.2.5.7	Humidity	x		x		x			
3.2.6	Transportability		x			x			
3.3	Design and Construction								
3.3.1	Parts, Materials and Processes		x			x	x	x	x
3.3.2	Electromagnetic Compatibility	x		x		x		x	

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		ANS	ISP	TST	DEM	INS	M C	ASY	UNT
3.3.3	Electrostatic Discharge Control		x			x	x	x	x
3.3.4	Nameplates and Product Marking		x			x	x	x	x
3.3.5	Fabrication Requirements		x		x	x	x	x	x
3.3.6	Interchangeability		x				x	x	x
3.3.7	Safety	x				x			
3.3.8	Human Performance/Human Engineering				x	x			
3.3.9	Software Requirements		x			x			
3.3.10	Contamination Control	x	x			x	x	x	
3.3.11	Leakage			x				x	
3.4	Documentation								
3.5	Logistics								
3.5.1	Maintenance								
3.5.2	Supply								
3.5.3	Facilities & Equipment								
3.5.4	GSE								
3.5.4.1	EGSE		x			x			
3.5.4.2	MGSE		x	x		x			
3.5.4.3	OGSE		x			x			
3.6	Personnel & Training								
3.6.1	Personnel								
3.6.2	Training								

Notes: ANS: Analysis; ISP: Inspection; TST: Test; DEM: Demonstration;
INS: Instrument; M C: Major Component; ASY: Assembly; UNT: Unit;
QUA: Qualification; ACT: Acceptance

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4.5

Test Tolerances

The following maximum allowable test tolerances shall apply to instrument tests. These tolerances apply only to test conditions, and do not include test equipment accuracies.

- a) Temperature
 - Max Temp: $\pm 2^{\circ}\text{C}$
 - Min Temp: $\pm 2^{\circ}\text{C}$
- b) Relative Humidity: $\pm 5\%$
- c) Pressure
 - > 100 torr: $\pm 5\%$
 - $1 \text{ torr} \leq P \leq 100$ torr: $\pm 10\%$
 - $0.001 \text{ torr} \leq P \leq 1$ torr: $\pm 25\%$
 - ≤ 0.001 torr: $\pm 80\%$
- d) Static Force: $\pm 5\%$
- e) Acceleration: $\pm 5\%$
- f) Vibration
 - Sine Amplitude: $\pm 10\%$ g peak
 - Sine Frequency: $\pm 2\%$
 - Sine Sweep Rate: $\pm 5\%$
 - Random Amplitude: $\pm 10\%$ g_{rms}
 - 10 - 500 Hz: ± 3.0 dB
 - 500 - 2000 Hz: ± 3.0 dB
- g) Acoustic Noise
 - 40 Hz and Below: + 3 dB, - 6 dB
 - Above 40 Hz, Below 3150 Hz: + 3 dB, - 3 dB
 - 3150 Hz and Above: + 3 dB, - 6 dB
 - Overall: + 1 dB, - 1 dB
- h) Mechanical Shock
 - Response Spectrum: + 25 %, - 10 %
 - Time History: $\pm 10\%$
- i) Mass Properties
 - Weight: ± 0.05 kg (TBC)
 - Center of Mass: ± 5 mm

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Moments of Inertia:	$\pm 10 \%$
Cross Products of Inertia:	$\pm 10 \%$
j) Frequencies	
20 Hz and Above:	$\pm 2 \%$
- - Below 20 Hz:	$\pm 0.5 \text{ Hz}$
k) Time:	$\pm 5 \%$
l) Electromagnetic Compatibility	
Voltage Magnitude:	$\pm 5 \%$ of the peak value
Current Magnitude:	$\pm 5 \%$ of the peak value
RF Amplitudes:	$\pm 2 \text{ dB}$
Frequency:	$\pm 2 \%$
Distance:	$\pm 5 \%$ of specified distance or $\pm 5 \text{ cm}$, whichever is greater
m) Magnetic Properties	
Mapping Distance Measurement:	$\pm 1 \text{ cm}$
Displacement of assembly center of gravity (cg) from rotation axis:	$\pm 5 \text{ cm}$
Vertical displacement of single probe centerline from cg of assembly:	$\pm 5 \text{ cm}$
Mapping turntable angular displacement:	$\pm 3 \text{ degrees}$
Magnetic Field Strength:	$\pm 1 \text{ nT}$
Repeatability of magnetic measurements (short term):	$\pm 5 \%$ or $\pm 2 \text{ nT}$, whichever is greater
Demagnetizing and Magnetizing Field Level:	$\pm 5 \%$ of nominal

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5.0 PREPARATION FOR DELIVERY

The Contractor shall prepare and implement procedures for the handling, storage, preservation, marking, labelling, packaging, packing and shipping of the Instrument.

5.1 Handling

The protection of the Instrument during the life of the program shall be achieved through the use of the handling equipment (including GSE) and techniques which have been certified before used. Evidence of initial and periodic proof-testing of handling equipment shall be maintained.

5.2 Storage, Preservation, Marking, Labelling, Packaging and Packing

The Instrument shall be stored, preserved, marked, labelled, packaged, and packed to prevent loss of marking, deterioration, contamination, or damage during all phases of the program. Stored and stocked items shall be controlled in accordance with documented procedures and be subjected to quality surveillance as stated in AD5. Contamination sensitive items shall be handled following the requirements in RD7.

5.3 Shipping

The contractor shall follow the shipping procedure as outlined in AD5 and defined in PD18. Contamination sensitive items shall be handled following the requirements in RD7.

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6.0

NOTES

6.1

Glossary of Terms

The following definitions have been employed in this document:

Instrument

The term Instrument implies MOPITT instrument. It consists of subsystems, modules and software which are mechanically or electrically interconnected to satisfy the functional and performance requirements of the MOPITT instrument.

Major Component

The term Major Component is used to refer to first tier hardware sub-divisions of the Instrument (e.g. optical subsystem).

Subsystem

The term Subsystem is used to refer to major components that have multiple critical items (e.g. optical subsystem, or cooler subsystem).

Critical Item

An item shall be considered a Critical Item if the technical complexity of the hardware item warrants an individual specification and is not broken down into lower level specification documents. A Critical Item may not be configured as a single physical element (e.g. PMC assemblies or TCMM).

Module

The term Module is used to refer to a single physical entity which typically is a critical item (e.g. TCMM, or PLDM).

Non-Complex Item

An item shall be considered a Non-Complex Item if it can be shown to be suitable for its application by inspection or demonstration.

Shall

Implies the requirement is applicable and must be verified.

Should

Implies the requirement is a guideline to be used during design.

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6.2

List of Acronyms and Abbreviations

The following acronyms and abbreviations have been employed in this document:

<u>Acronym</u>	<u>Meaning</u>
APID	Application Process Identification
BDU	Bus Data Unit
bps	bits per second
CCSDS	Consultative Committee for Space Data Systems
C&DH	Command and Data Handling
CDR	Critical Design Review
cg	Center of Gravity (or Center of Mass)
CH ₄	Methane
CO	Carbon Monoxide
CSA	Canadian Space Agency
CVCM	Collected Volatile Condensable Material
EGSE	Electrical Ground Support Equipment
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EOS	Earth Observing System
FMEA	Failure Modes and Effects Analysis
FOV	Field Of View
GE	General Electric
GFE	Government Furnished Equipment
GIIS	EOS General Instrument Interface Specification
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
ICF	Instrument Calibration Facility
ICM	Instrument Controller Module
ID	Identification
IFOV	Instantaneous FOV
in	inch
IR	Infrared
I&T	Integration and Test
kg	kilograms
kbps	kilobits per second
LMC	Length Modulator Cell
LMR	Length Modulator Radiometer
LSB	Least Significant Bit
mb	millibar
MDD	Mission Design Description
MGSE	Mechanical Ground Support Equipment

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