IMAGE
INSTRUMENT SPECIFICATION
FOR THE
EXTREME ULTRAVIOLET IMAGER (EUV)

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Revision 2 Change 0
Contract NAS5-96020

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LIST OF TBDs

Paragraph	Description

PURPOSE

The purpose of this Instrument Specification is to document the instrument developer's response to the technical and programmatic requirements of the NASA Explorer/IMAGE Level 1 Requirements Definition (as defined in the GSFC statement of work to SwRI contract NAS5-90620) and the IMAGE mission in terms of compliance, detailed specification, and special requirements.

This document will be used as the basis for spacecraft/instrument interface requirements, for functional and performance specifications, and for verification; therefore, it is important that this document contain information that is as complete as possible. Where final numerical values are not available, best estimates should be given and so noted. Items not applicable to an instrument shall be indicated by N/A. Items not yet defined shall be indicated as **TBD**.

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LIST OF ACRONYMS

CDR	Critical Design Review
CG	Center of Gravity
CIDP	Central Instrument Data Processor
EGSE	Electrical Ground Support Equipment
EUV	Extreme Ultraviolet imager
FOV	Field of View
GSE	Ground Support Equipment
HV	High Voltage
HVPS	High Voltage Power Supply
ICD	Interface Control Drawing
IMAGE	Imager for Magnetopause-to-Aurora Global Exploration
LVPS	Low Voltage Power Supply
LMMS	Lockheed-Martin Missiles and Space

MCP	Microchannel plate
MGSE	Mechanical Ground Support Equipment
MICD	Mechanical Interface Control Drawing
MIME	Multipurpose Internet Mail Extensions
RDM	Radiation Dose Margin
RPI	Radio Plasma Imager
SCU	System Control Unit
SI	Science Instrument
TLM	Telemetry
UV	Ultraviolet
WSZ	Wedge, Strip and Zigzag

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1. SCOPE, OBJECTIVES, AND DESCRIPTION

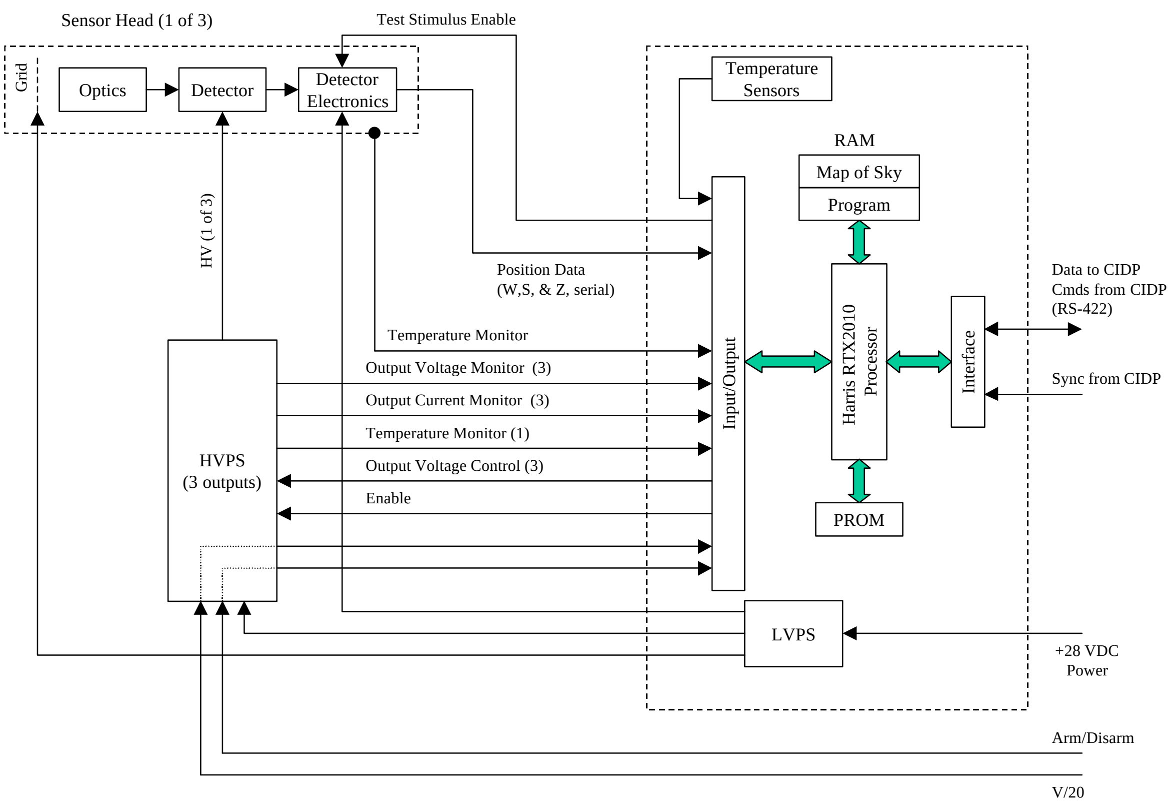
1.1 Mission

The EUV instrument is intended to determine the He^{+} distribution in Earth's plasmasphere by imaging 30.4-nm sunlight that has been resonantly scattered by plasmaspheric He^{+}.

1.2 General Description

1.2.1 Hardware Description

The Extreme Ultraviolet Imager (EUV) measures He^{+} 30.4-nm emissions from Earth's plasmasphere. The EUV consists of three identical sensor heads mounted on a common bracket and serviced by a common electronics module called the EUV Controller. A block diagram is shown below. Each sensor head has a cone-shaped field of view of 30° full angle. The three sensors are tilted relative to one another to cover an ×30°. The long dimension of the field lies in the plane of the satellite's spin axis, and its center is perpendicular to the spin axis. As the satellite spins, the fan sweeps a ×360°-swath across the sky, mapping 67% of 4π steradians.



Optics, Detector, and Sensitivity. Each EUV sensor head employs a single spherical mirror. A multilayer reflective coating on the mirror selects a narrow passband around the 30.4-nm line. By limiting the range of incidence angles of rays arriving at the mirror, the annular entrance aperture assures near optimum performance of the multilayer coating. To circumvent the red leak in the multilayer mirror, a short-pass filter blocks H Lyman α contamination from the geocorona and from the interplanetary wind. The spatial resolution of the optics is ~0.6°, or ~0.1 R_E in the equatorial plane seen from apogee. The effective spatial resolution can be adjusted to the needs of a particular experiment by summing pixels. The mirror focuses incoming light on the detector, a triple microchannel plate (MCP) electron multiplier with a 2-D wedge-and-strip anode for readout. Its spherical input surface minimizes the effects of spherical aberration. The sensitivity (accounting for the duty cycle inherent in spinning) is 0.2 count/(sec pixel) per Rayleigh, where the pixel size is taken to be 0.1 R_E from apogee. See Section 3.2.1.1 for a diagram of a sensor head.

Electronics. Each sensor head has its own preamplifiers and position-finding circuitry. Positions of individual photoevents are transferred to the EUV Controller, which includes a microprocessor, a RAM buffer and program space, ROM, A/D converters for housekeeping information, and the required I/O capability. The Controller accepts commands from the CIDP to select operating modes. The CIDP provides a spin-phase sync signal to the EUV, including markers for spin phase relative to the nadir and to the Sun.

Operation. A key element in the operation of the EUV is the RAM buffer, which stores a 2-D array of brightness measurements; each element in the array corresponds to a particular spatial resolution element in the sky. EUV keeps track of the satellite's spin phase, so the Controller can relate the position of each detected photon to a position in the sky. It then increments the value of the corresponding array element. After a number of spins corresponding to the desired time resolution, the EUV transfers the sky map data to the CIDP, which compresses the image and formats it for the telemetry stream.

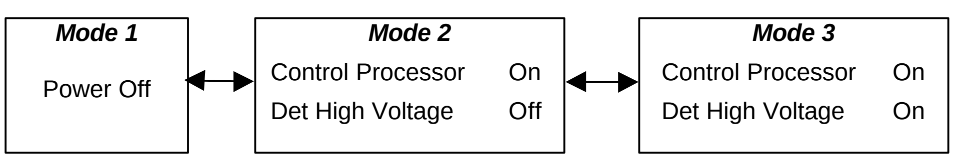
At some times during the IMAGE Mission, the Sun may enter the field of one (and, rarely, two) of the sensor heads at some spin phases. No useful data can be recorded from the affected sensor head with the Sun in the field, and we will reduce the high voltage to the MCP's to avoid excessive counting rates. EUV uses the Sun-position pulse from the CIDP to implement this. The filter will prevent damage to the detector by focused visible sunlight.

1.2.2 Software Description

Control software for the EUV is written in C and assembly language. The software will keep track of the satellite spin phase by counting roll phase pulses from the CIDP. These pulses will be digital levels on a dedicated line. The Controller will perform all data processing necessary to create the sky map, and will output the skymap data to the CIDP. The Controller will also provide engineering monitor data and housekeeping data to the CIDP. The Controller will accumulate a pulse height distribution for each sensor head. The software will have the capability to compensate for the effect of a misalignment of the spin axis relative to the s/c Z axis if the spin axis is known relative to the observatory system and the mis-alignment is less than 5º. The CIDP will time-tag the data from the EUV, compress them, and format them for the telemetry stream. Data transfers from the EUV Controller to the CIDP will be initiated by the EUV Controller shortly after a nadir marker, and will be completed before the following nadir marker.

1.2.3 Operational Modes

Power modes are summarized in the following diagram:



The arrows mark permitted transitions between modes.

Mode 3: Detector processing can be standard or diagnostic.

Modes 2 & 3: Engineering data rate can be high or low.

EUV will form maps of the sky of size 84°×360°. EUV will buffer data internally as it builds up the map of the sky photon-by-photon. The nominal exposure time will be 10 minutes (5 spin periods). The Controller will send data from one of the three heads to the CIDP on each of three successive rolls. During the following two rolls, EUV will transmit no map data to the CIDP. Each data transmission will begin shortly after a nadir marker and will be completed before the next nadir marker.

The spatial resolution of the image will be ~0.6 degree and each resolution element will be represented by a 16-bit word. Therefore the image size for a complete sky map (all three sensor heads) will be 1.4E6 bits.

1.3 Operational Concepts

1.3.1 Ground Operations.

EUV will be operated in a vacuum calibration chamber having a source of UV light of known flux and wavelength to determine absolute system throughput, spatial resolution, field of view, out-of-band response, etc. The EUV EGSE will be used for commanding and data readout. During vacuum chamber operations, simulated orbit operations (including testing of the spin-sync functions), HV ramp-up, and error condition scenarios will be carried out as part of operations crew training. A protective cover for the aperture will be fitted at all times except during thermal vacuum testing. The cover will be transparent at wavelengths used for EMI testing.

1.3.2 Integrated System Testing

EUV will conduct only aliveness checks during integrated systems testing. Commanding and TLM readout through the mission EGSE (ASIST workstation working in tandem with EUV EGSE) will be verified by simulated data packets as well as by command and response to the instrument in low-voltage mode. The EUV will have the capability of operating in a test-pulse mode, in which test pulses simulating detected photons are injected at an early stage in the analog signal processing chain. A protective cover for the aperture will be fitted at all times except during thermal vacuum testing. The cover will be transparent at wavelengths used for EMI testing.

1.3.3 On-Orbit Operations and Testing

EUV orbit operations will follow scripts and procedures worked out in instrument-level ground testing. Use of the ASIST ground station will be standard. The EUV timeline calls for outgassing for at least 2 weeks, activation of HVPS and ramp up over 3 days, and collection of images as possible while the observatory is spinning at 0.5 rpm during early orbit operations. Science operations will commence when the RPI antennas are fully deployed and the observatory roll is stabilized at 0.5 rpm.

1.4 Organizational and Management Relationships

EUV will be designed and built by the University of Arizona under the direction of Bill Sandel.

2. APPLICABLE DOCUMENTS

2.1 Parent Documents

This document shall be governed by the Image System Specification. All requirements enumerated herein shall be traceable to the Image System Specification or to interface documents such as the Spacecraft to Payload Interface Control Document

2.2 Government Furnished Property List

None required.

2.3 Other Applicable Documents

Other documents applicable to or partially referenced in this document are as follows:

NASA

NHB 1700.1	NASA Safety Policy and Requirements Document
NHB 5300.4(3A-2)	Requirements for Soldered Electrical Connections
NHB 5300.4(3G)	Requirements for Interconnecting Cables, Harnesses and Wiring
NHB 5300.4(3H)	Requirements for Crimping and Wire Wrap
NHB 5300.4(3I)	Requirements for Printed Wiring Boards
NHB 5300.4(3J)	Requirements for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies
NHB 5300.4(3K)	Design Requirements for Rigid Printed Wiring Boards and Assemblies
NHB 6000.1D	Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems, Equipment, and Associated Components

Military

MIL-E-45782B	Electrical Wiring, Procedure for Amendment 1
MIL-H-6088F(1)	Heat Treatment of Aluminum Alloys
MIL-HDBK-5E	Metallic Materials and Elements For Aerospace Vehicle Structures
MIL-I-6870E	Inspection Program Requirements, Nondestructive For Aircraft and Missile Materials and Parts
MIL-STD-750C	Test Methods for Semiconductor Devices

MIL-STD-883D	Test methods and Procedures for Microelectronics
MIL-STD-981B	Design, Manufacturing, and Quality Standards for Custom Electromagnetic Devices for Space Applications
MIL-STD-975M	NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List
MIL-STD-1686A	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically initiated Explosive Devices)
MIL-STD-810D-1	Environmental Testing Methods and Engineering Guidelines
MIL-STD-889B	Dissimilar Metals
MIL-STD-461C	Military Standard Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility.
MIL-STD-462	Measurement of Electromagnetic Interference Characteristics

Industry

ANSI/EIA-232-D-1986	Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

SwRI

PAIP 96-15-8089	Performance Assurance Implementation Plan for the Medium Explorer Magnetopause-To-Aurora Global Exploration (IMAGE)
EUVI-PAIP-001	Performance Assurance Implementation Plan for MIDEX Mission Extreme Ultraviolet Imager Investigation.

3. REQUIREMENTS

3.1 Functional Requirements

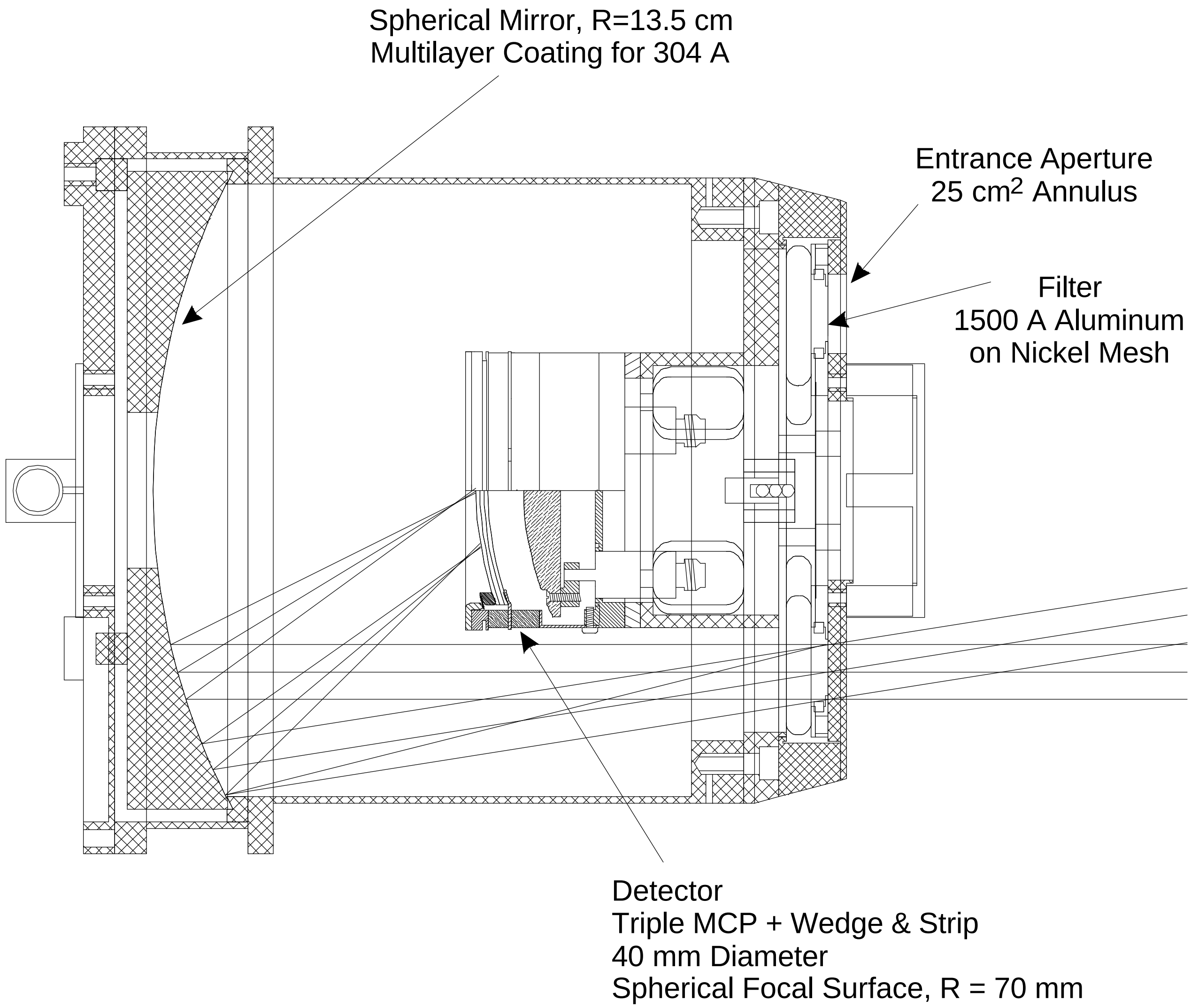
The EUV Instrument shall collect images by focusing and detecting 30.4-nm light from He^+ in the plasmasphere. The resolution, field of view, sensitivity, and other characteristics of the collected images shall be as described below and be in accordance with the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) Level 1 Requirements Definition. It shall interface to the IMAGE Central Instrument Data Processor for telemetry and commanding as defined below and in the CIDP-to-SI ICD.

3.2 Performance Requirements

3.2.1 Sensor Head

3.2.1.1 General Description

An EUV sensor head consists of a housing, filter assembly, multilayer mirror, and detector assembly as described in section 1.2.1. and shown below. Each sensor head has a dedicated detector electronics box that is mounted separately from the head.



3.2.1.2 Spatial Resolution

EUV shall have a spatial resolution of 640 by 640 km/pixel at 7 R_E.

3.2.1.3 Wavelength

EUV shall image resonantly scattered sunlight from plasmaspheric He^+ at 30.4 nm.

3.2.1.4 Imaging Frequency

EUV shall collect 1 image in 10 minutes during normal science operations.

3.2.1.5 Sensitivity

EUV shall have a sensitivity of at least 0.2 counts/(sec Rayleigh pixel) for a pixel size of 0.6°×0.6°.

3.2.1.6 Field of View

EUV shall have an instantaneous field of view of at least 30° in azimuth by 84° in elevation (relative to the rotational equator of the spacecraft). During one roll period, EUV shall sweep out an 84° (centered on the

3.2.2 Electronics Module

3.2.2.1 Memory

The EUV shall have RAM memory of 256k × 16 bits, sufficient for operating program and parameters, and storage of a complete map of the sky from the three sensor heads, pulse height distributions, and engineering data.

3.2.2.2 Communications to Sensor Head

The following table summarizes communications between the Detector Electronics and the Controller.

Detector Electronics-Controller Communications

Signal	*Source*	*Receiver*	*Carrier*
Data	Detector Elec.	Controller	Differential Serial
Data Ready	Detector Elec.	Controller	Differential Digital
Data Clock	Controller	Detector Elec	Differential Digital
Event Count	Detector Elec.	Controller	Differential Digital
Test Pulse	Controller	Detector Elec	Differential Digital
Test Pulse Enable	Controller	Detector Elec	Differential Digital

3.2.2.3 Processor Throughput

Processor throughput shall be sufficient to acquire data from the sensor heads, process it as required, buffer the data, transmit it to the CIDP, receive and process commands from the CIDP, and perform other functions required for normal operations and for diagnostic processing.

3.2.2.4 High Voltage Power Supply Control

The Controller shall be able to command the HVPS to alter the voltage to the detectors individually as needed.

3.2.2.5 Data Collection Requirements

The Detector Electronics shall transmit to the Controller position data corresponding to each detected and processed photon in the form of digitized anode wedge, strip, and zig-zag (WSZ) signals. The Detector Electronics shall provide the Controller with a logic pulse corresponding to each detected photoevent, whether it is processed or not. The Controller shall be capable of handling WSZ signals at a rate of 50 kHz.

The Controller shall monitor analog data from the HVPS and digitize it. These data shall include:

Output Current for Sensor Head 0

Output Voltage for Sensor Head 0

Output Current for Sensor Head 1

Output Voltage for Sensor Head 1

Output Current for Sensor Head 2

Output Voltage for Sensor Head 2

HVPS Temperature

The Controller shall communicate with the CIDP as described in section 3.3.4.

3.2.2.6 Electronics Unit Embedded Software

3.2.2.6.1 General Description

The Controller Embedded software shall support all the necessary command, data handling, and communication functions for the EUV instrument.

3.2.2.6.2 Software Configurations

The flight software will be executed in the EUV instrument's single controller. This controller shall communicate with the CIDP over the RS-422 interface, monitor spacecraft spin, transmit the collected science data, and monitor the instrument status. The CIDP shall store and re-transmit the data stream that the instrument produces. Other than data compression, no special data handling is required. The CIDP shall store time-tagged commands so that a sequence of commands can be performed between the times that ground stations are in direct contact with the satellite. The CIDP shall store for EUV in non-volatile memory up to four blocks of data of no more than 64k bytes each and totaling no more than 128k bytes. These blocks may be loaded before launch or from the ground by commands to the CIDP. If the EUV instrument is power cycled or at any other time, any block shall be available for transmission to EUV by EUV request or by ground command. See also Section 1.2.2., Operational Sequence and Characteristics.

3.2.2.6.3 Operational Sequence and Characteristics

There are 3 operational modes, as described in Section 1.2.3. The normal science mode is Mode 3.

3.2.3 Power Supply Module

3.2.3.1 Supply to Sensor Head

The Power supply module shall supply the following voltages to the Detector Electronics:

+5 V	Digital Electronics	max current: 153 ma
+15 V	Analog Electronics	max current: 24 ma
-15 V	Analog Electronics	max current: 105 ma

The Power supply module shall supply the following voltages to the High Voltage Power Supply:

+5 V	Digital Electronics	max current: 0 ma
+15 V	Analog Electronics	max current: 182 ma
-15 V	Analog Electronics	max current: 33 ma

3.2.3.2 Supply to Electronics Module

The power supply module shall supply the Instrument Controller with 4.9 watts at +5, ±15 volts.

3.2.3.3 Safe-mode Performance

When commanded to enter Mode 2, the power supply shall ramp down the voltages supplied to the sensor head in such a fashion as to prevent damage to the sensor head under all circumstances.

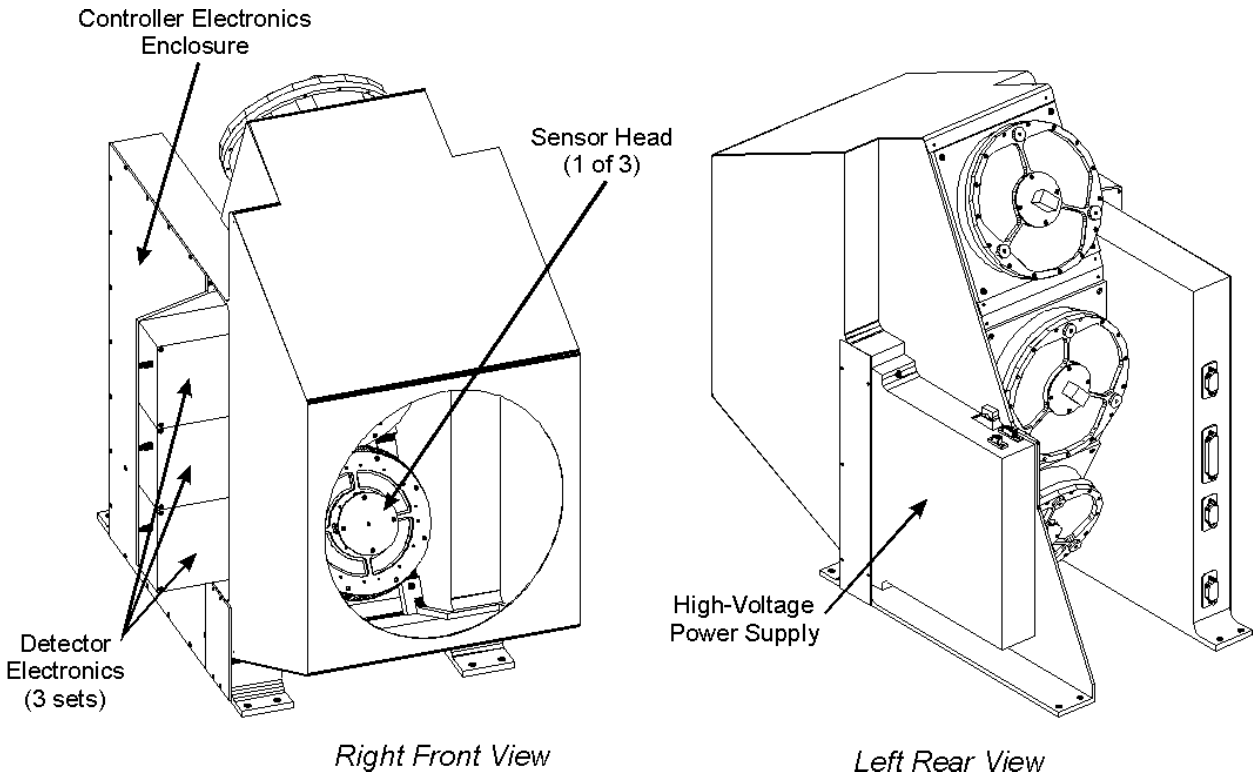
3.2.3.4 Transient (Turn-on and Turn-off) Performance

Turn-on transient current draw will comply with the requirements of the Image System Specification and will draw a maximum transient current ≤ 3 A. EUV power supplies will be designed to prevent damage to the sensor head and electronics if spacecraft power is unexpectedly removed from the instrument.

3.3 Interfaces

3.3.1 Mechanical

The three EUV sensor heads are mounted one above the other in a common bracket, which is in turn mounted to the payload deck plate. The EUV Controller, HV power supplies, and the detector electronics are attached to the sides of the bracket. The base of the bracket forms the only mechanical interface between EUV and the spacecraft. No intra-instrument cables touch the payload deck plate or other



elements of the spacecraft. The sensor heads share a common aperture formed by a cutout in the spacecraft skin.

3.3.1.1 Mechanical Dimensions

See the attached MICD for the mechanical layout of the sensor heads and the brackets.

3.3.1.2 Mass Properties

The mass of EUV shall not exceed 15.6 kg.

Table 3-0: Mass Properties Summary

Component	Mass (g)
Side Support (Electronics)	2640
Electronics Recess Cover	820
Side Support (HV Supply)	1790
HV Connector Recess Cover	44
Entrance Baffle	225
Rear Baffles	13
Controller Board & Connectors	610
LV Converter Board	190
Power Distribution Shelf	69
HV Cable Supports	40
Purge Hardware (header, clamp, filter, tubing)	96
HV Supply and Housing	1650
Detectors (3 @ 200 gms)	600
Detector Electronics Assys (3 @ 380 gms)	1140
Detector Electronics Support Plate	260
Sensor Housings (3 @ 880 gms)	2640
Mirrors (3 @ 470 gms)	1410
Mirror Support Rings (3 @ 17 gms)	51
Entrance Filter Assemblies (3 @ 40 gms)	120
Cable Set, HVPS to Controller	158
Screw Fasteners	250
Internal Cabling	264
Misc. Hardware	500
Total	**15580**

3.3.1.3 Instrument Center of Mass

The center of mass is shown on the MICD.

3.3.1.4 Radiation Design

The radiation design philosophy is based on the doses computed at GSFC and supplied by SwRI. It achieves a radiation design margin (RDM) of 2. Controller parts have a minimum survival capability of 100 kRad. To achieve an RDM = 2, sufficient shielding is provided by the Controller enclosure to reduce the total dose to 50 kRad. The graphs of total dose vs. shielding thickness show that approximately 0.17 inch Al is required. Allowing for 0.02-inch Al equivalent provided by the spacecraft structure, the wall thickness shall be 0.15 inch Al to provide sufficient radiation shielding. Similar strategies are being implemented for the detector electronics and HVPS.

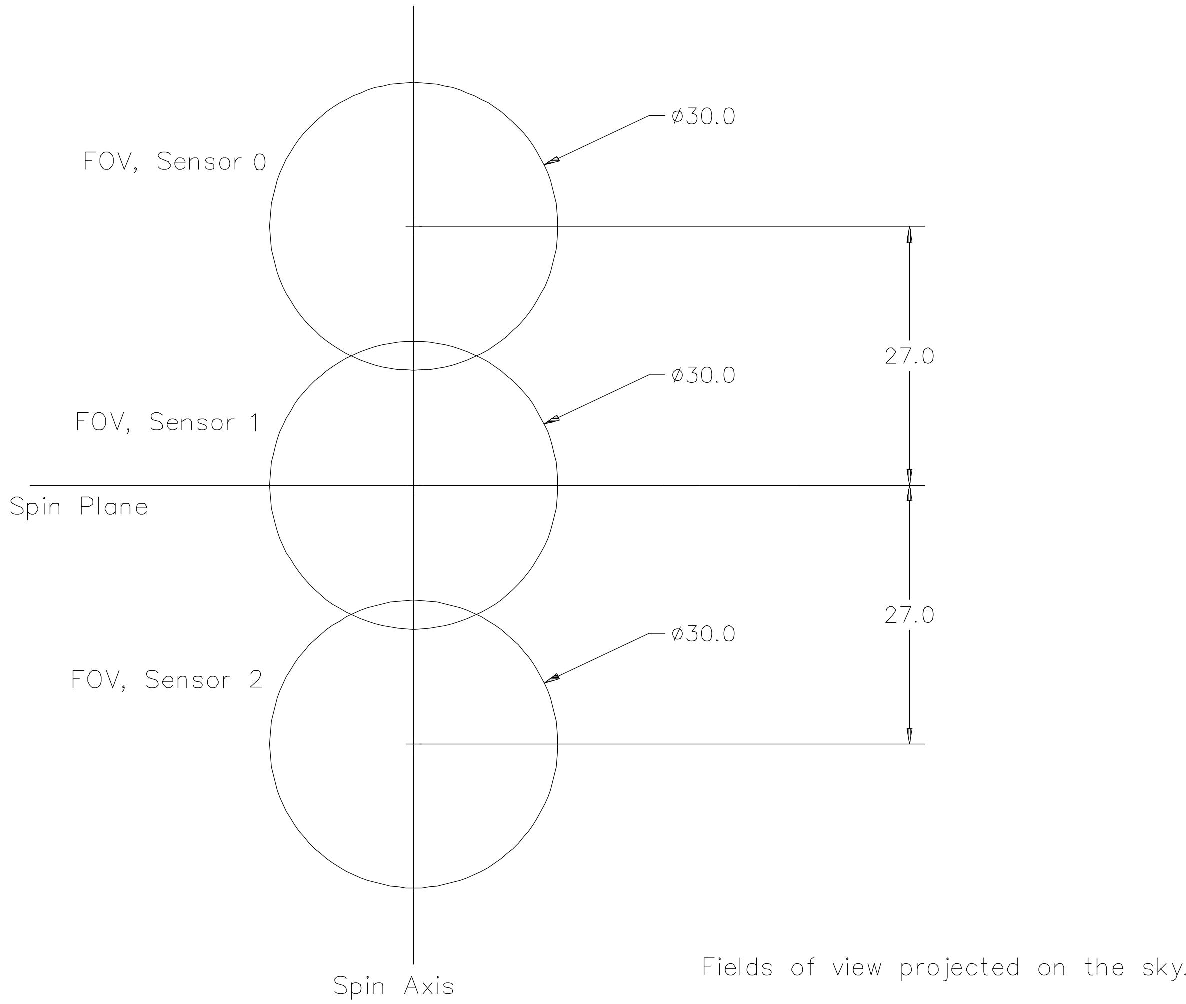
3.3.1.5 Deployables

None

3.3.1.6 Field-of-View and Clear Fields

The drawing below shows the nesting of the fields of view of the three sensors. The most important aspect is the spacing of the centers of the fields from the plane that is perpendicular to the spin axis (labeled "Spin Plane" in the drawing). The centers of the fields shall be oriented parallel to the plane (Sensor 1) and tilted ±27° (Sensors 0 and 2) from parallel to that plane.

See MICD for constraints on obstructions near the EUV FOV.



3.3.1.7 Alignment

The alignment shall be ±0.1° for relative positions of the fields of the three sensor heads. The relative position of the fields of view is determined by the bracket and so is not a s/c interface issue.

There shall be control of ±0.2° for elevation relative to the spin axis.

There shall be knowledge of ±0.2° for azimuth relative to the roll phase fiducial.

There shall be control of ±0.2° for clock, i.e. rotation of the fields about their optic axis.

3.3.1.8 Handling

Detector high voltage may not be turned on unless the sensor heads have been at a pressure of less than 5×10^{-6} torr for 4 hours or more. The standard procedures should be consistent with handling of optical instruments. There shall be no solvents other than isopropyl alcohol used on or in the immediate vicinity of the EUV after its attachment to the payload deck. There shall be no wipes used on or in the immediate vicinity of the instrument unless the aperture cover is in place. (See Section 3.4.6 for more information.)

3.3.1.9 Remove-Before-Flight Items

There shall be a remove-before-flight cover over the entrance aperture. The HV safing plug shall be removed/exchanged before launch. This plug is part of the common instrument HV arm/disarm plug.

3.3.2 Electrical

3.3.2.1 Power

The EUV instrument shall not consume more than 16.5 W of orbit average power. Its peak power consumption shall not exceed 16.5 W. It is powered from the 28 Volt spacecraft supply. All other voltages required by the instrument are generated internally by DC to DC converters. Table 3-1 describes the power supply requirements for the EUV instrument. Peak power is the power required at the input voltage 22<Vmax<34 giving the maximum power (Vmax=34 V).

Table 3-1: Power Supply Voltages and Currents Required by the EUV Instrument

Input V (Volts)	**Average I** (mA)	**Peak I** (A)	**Average P** (Watts)	**Peak P** (Watts)
+34	485	3	16.5	16.5

3.3.2.2 Power Profile and Peak Power

The EUV instrument has three modes of operation. Table 3-2 profiles the power consumption required in each operational mode as described in Section 1.2.3.

Table 3-2: Power Profile for the EUV Instrument

Operational Mode	**Power Consumption**	**Peak Power**
Mode 1	0 Watts	0 Watts
Mode 2	12.5 Watts	12.5 Watts
Mode 3	16.5 Watts	16.5 Watts

3.3.2.3 Cables

External cables will be supplied by SwRI. Those cables shall provide

1) Power
2) Command, sync, and data interface
3) HV arm/disarm

3.3.2.4 Connectors

The EUV instrument is operated through three electrical cables. The EUV Data Cable provides all command and data communication to the instrument. The EUV power cable provides power to the instrument. The EUV Arm/Disarm cable provides high-voltage safing.

All power for the instrument is provided through the EUV Power Cable, which connects to the 9 pin male Subminiature-D connector labeled 16P122 on the rear of the instrument. Table 3-3 lists the pin assignments for this connector.

All command and data communication takes place over the EUV Data Cable, which connects to the 15 pin male Subminiature-D connector labeled 16P121 on the rear of the instrument. Table 3-4 lists the pin assignments for this connector.

Table 3-3: EUV Power Cable Pinout.

Connector Number: 16P122 Type: Subminiature D Connector (9D, Pin) SND9M

Pin Number	Signal Name	Signal Description	Category	Code	AWG
1	CGND	Chassis Ground	1	S	20
2	28 V	+28 V Power Supply	1	T2	20
3	28 V	+28 V Power Supply	1	T2	20
4	28 V RET	Power Return	1	T2	20
5	28 V RET	Power Return	1	T2	20
6	NC				
7	NC				
8	NC				
9	NC				

Table 3-4: EUV Data Cable Pinout

Connector Number: 16R121 Type: Subminiature D Connector (15D, Pin) SDD 15M

Pin Number	Signal Name	Signal Description	Category	Code	AWG
1	CGND		2	S	24
2	Data to CIDP+	Cmd/Data	2	T2	24
3	Data to CIDP-	Cmd/Data	2	T2	24
4	NC				
5	NC				
6	NC				
7	Shield	Gnd/Shield	2	S	24
8	Shield		2	S	24
9	Shield		2	S	24
10	NC				
11	Command from CIDP+	Cmd/Data	2	T2	24
12	Command from CIDP-	Cmd/Data	2	T2	24
13	SYNC+	Syncro Pulse	2	T2	24
14	SYNC-	Syncro Pulse	2	T2	24
15	NC				

Table 3-5: EUV HV Arm/Disarm Cable Pinout.

Connector Number:16R501 Type:Subminiature D Connector (9D, Socket) SND9F

Pin Number	Signal Name	Signal Description	Category	Code	AWG
1	CGND	Chassis Ground	2	S	24
2		EUV Disable –	2	T2	24
3		EUV Disable Return	2	T2	24
4		EUV Safe –	2	T2	24
5		EUV Safe Return	2	T2	24
6	NC				
7	NC				
8	NC				
9	NC				

Note: Cat: 1 = power, 2 = Digital, 3 = Analog Code: Tn = Twisted shielded with (n) wires twisted and located in twist group, S = Shield

1S = Single shielded wire

U = Unshielded

3.3.2.5 Grounding

The HVPS and detector electronics shall be designed to connect to chassis ground at each sensor head. There will be an additional chassis ground at the output of the low-voltage power supplies.

3.3.2.6 Safety Connectors

The high voltage inhibit connector on EUV shall be replaced with an arming harness which brings the inhibit function to the red-tag connector on the payload purge/arm bracket prior to launch.

3.3.2.7 Timing Requirements

There shall be information on satellite roll phase given to EUV to synchronize accumulation of an internally-generated map of the sky. The EUV Controller accepts roll phase information in the form of digital pulses that occur at intervals of 0.1° in roll phase. These pulses are provided on a dedicated sync line. A double pulse will occur at times for which the nadir lies in the s/c XZ plane, in the +X half-plane.

There shall be information given to EUV on the position of the Sun in roll phase in order to protect sensor heads while the Sun is near or in the field of view. This information will be provided as a triple pulse on the sync line. The triple pulse will occur at times for which the center of the Sun lies in the s/c XZ plane, in the +X half-plane.

3.3.3 Command and Data Handling

3.3.3.1 Power On/Off Commands

Power on/off command controls main power from the CIDP to the EUV Controller. Once the instrument is powered up and operating normally, there is no known requirement to switch power.

3.3.3.2 Memory Load Commands

Memory Load Commands shall be in accordance with the specifications listed in the CIDP Instrument Specification, Section 4.1.3.2.4.

3.3.3.3 Serial Digital Data

In Modes 2 and 3, EUV telemeters the full mapping data set along with engineering data. EUV buffers data internally and transmits it to the CIDP beginning at a nadir marker. EUV data packets conform to the format specified in the CIDP-to-Instrument Interface Control Document (8089-CIICD-01). Table 3-6 summarizes the characteristics of each EUV data packet. The format of each packet is defined in detail in Excel spreadsheet files that conform to the standard established by GSFC. Table 3-6 shows the names of each of these files, which are in the frio account in Databases/EUV/Release1.

Table 3-6. EUV Telemetry Packets

ApID	Packet Name	Size (bytes)	File Name
0x03	Skymap 0	62440	skymap0-3-95.xls
0x05	Skymap 1	62440	skymap0-3-95.xls
0x0E	Skymap 2	62440	skymap0-3-95.xls
0x12	Pulse Height Histogram 0	2088	histogram-95.xls
0x14	Pulse Height Histogram 1	2088	histogram-95.xls
0x17	Pulse Height Histogram 2	2088	histogram-95.xls
0x22	Event Count 0	7240	eventcount0-95.xls
0x24	Event Count 1	7240	eventcount0-95.xls
0x27	Event Count 2	7240	eventcount0-95.xls
0x28	Diagnostic Housekeeping Data	38444	status-95.xls
0x30	EUV status	2088	status-95.xls
0x33	WSZT 0	62440	wszt0-3-95.xls
0x35	WSZT 1	62440	wszt0-3-95.xls
0x3E	WSZT 2	62440	wszt0-3-95.xls
0x43	Skymap 0, Calibration mode	---	(not used in flight or I&T)
0x45	Skymap 1, Calibration mode	---	(not used in flight or I&T)
0x4E	Skymap 2, Calibration mode	---	(not used in flight or I&T)
0x00	Memory Dump	0x00	memdump-95.xls

During nominal science operations, EUV transmits data in the sequence in Table 3-7. One complete EUV cycle is completed every 5 spins = 10 minutes.

Table 3-7 EUV Telemetry Sequence

Spin	Packet Type	Size (bytes)
Spin 0	Skymap 0	62440
	Event Count 0	7240
	Histogram 0	2088
	Status	2088
Spin 1	Skymap 1	62440
	Event Count 1	7240
	Histogram 1	2088
	Status	2088
Spin 2	Skymap 2	62440
	Event Count 2	7240
	Histogram 2	2088
	Status	2088
Spin 3	Diagnostic Housekeeping	38444
	Status	2088
Spin 4	Status	2088
	Total for 5 spins	**264,188**
	Total for 13.5 hours	**21,399,228**
	Total for 24.0 hours	**38,043,072**

3.3.3.4 Health and Safety

The EUV shall meet the GSE safety requirements described in section 3.2.8.2 of the IMAGE System Specification.

3.3.4 Central Instrument Data Processor

The CIDP is responsible for passing EUV commands from the telemetry uplink to EUV over the RS-422 interface. The CIDP will also receive data packets from the EUV instrument, compress them, add telemetry information, and pass them on to the SCU for transmission to ground stations during the next available telemetry window.

3.3.4.1 Data Transfer Rate

Data from the EUV instrument shall be transferred to the CIDP at an average rate of 38,400 bits per second. During any 13.5-hour spacecraft orbit period, the total amount of data transferred shall be limited to 21,399k bytes.

3.3.4.2 CIDP Processing Requirements

The CIDP shall time-tag data frames from the EUV, compress them using a lossless compression algorithm, and format them for the telemetry stream.

3.3.4.3 Processing Rate

CIDP needs to compress and format for telemetry one set of 3 EUV skymaps and engineering data every 10 minutes during normal operations. See 3.3.3.3 for image size.

3.3.4.4 Uncompressed Data Storage Requirements

The total uncompressed storage for all of the data generated by the EUV instrument in one 24 hour period shall be 38,043k bytes. Assuming a 1.8 to 1 compression factor, this data could be stored in 21,135k bytes. Some margin must be added to these numbers to account for the telemetry packet header information which the CIDP will add to our packets.

3.3.4.5 Instrument Control Functions

The instrument shall be controlled by commands from the CIDP. These commands are described in the file EUVcmd004-95.xls, which is in the frio account in Databases/EUV/Release1.

3.3.4.6 Instrument Safe Requirements

In case of an emergency need to reduce power consumption, the safing steps are

If in Mode 3, switch to Mode 2. (See 1.2.3 for definition of operating modes.)

If in Mode 2, switch to Mode 1.

3.3.4.7 Preferred Protocol for Serial Interface

EUV shall conform to the description of the serial interface in the CIDP Specification (Rate = 38,400 bps, 8 data bits, no parity, differential RS-422.)

3.3.5 Thermal

3.3.5.1 Thermal Design Requirements

The thermal design of the EUV shall be such as to maintain all elements of EUV within their temperature ranges as described in 3.3.5.6, given spacecraft thermal properties within the nominal limits.

3.3.5.2 Thermal Design Concept

Conduction is expected to be the main mechanism of heat transport, with radiation to space and to other elements of the payload playing a relatively minor role. The design will model both mechanisms of transport.

3.3.5.3 Thermal Interfaces

The primary mechanism for heat transport from EUV will be by conduction to the payload deck plate.

The thermal interface to the payload deck plate shall be through the base of the bracket.

3.3.5.4 Thermal Finish

The surfaces shall be class 3 alodyned aluminum throughout.

3.3.5.5 Temperature Range

An operating temperature range of -25°C to +40°C with a non-operating range of -50°C to +60°C is acceptable. There are no spatial or temporal gradient requirements. The switch-on temperature range shall be: -25°C to +40°C. The temperature stability shall be 15°C /hour.

3.3.5.6 Temperature Monitoring

There shall be temperature monitors for the HVPS, the Detector Electronics, each sensor head, the controller board, and the low-voltage power converters.

3.3.5.7 Thermal Analysis and Predictions

Preliminary thermal analysis indicates that for a deck plate temperature of -10 C, EUV temperatures will range from -1 C to -13 C. For a deck plate temperature of +10 C, EUV temperatures will range from +10 to +22 C.

3.4 Other Design Requirements

3.4.1 Environments

The EUV shall conform to the environmental requirements described in section 3.1 (Observatory Environments) of the IMAGE System Specification.

3.4.2 Life

The EUV shall meet the lifetime and operational availability requirements described in section 3.2.3 (Operational Availability) of the IMAGE System Specification.

3.4.3 Reliability

The EUV shall meet the reliability requirements described in section 3.2.5 (Reliability) of the IMAGE System Specification.

3.4.4 Maintainability and Storage

EUV shall meet the maintainability and storage requirements described in section 3.2.6 (Maintainability) and Section 3.2.9 (Storage) of the IMAGE System Specification.

3.4.5 Safety

3.4.5.1 Transportation Safety

EUV shall meet the transportation safety requirements described in section 3.2.7.1 (Transportation Safety) of the IMAGE System Specification.

3.4.5.2 GSE Safety

EUV shall meet the GSE safety requirements described in section 3.2.7.2 (GSE Safety) of the IMAGE System Specification.

3.4.6 Special Materials & Processes Constraints

3.4.6.1 Sensitive Components

Multilayer coatings on the mirrors are sensitive to contamination, especially by hydrocarbons.

The microchannel plates are sensitive to contamination by hydrocarbons, water vapor, and particles.

The thin filters are sensitive to contamination and mechanical damage.

3.4.6.2 Limits

See the allowable temperature range in section 3.3.5.6 and the purge requirements in section 3.4.6.5.

3.4.6.3 Protection

Purge for ground handling and pre-launch. Time without purge: 30 consecutive minutes acceptable, in Class 10,000 or better. No contamination issues expected in orbit.

3.4.6.4 Purge Connector

There shall be a single purge connector to the payload purge system. EUV shall distribute the purge to the three sensor heads. The purge connector (PMCD 10-02V) will mate with the payload purge line connector on one end and have a male 1/8 NPT thread on the other.

3.4.6.5 Purging

EUV shall be constantly purged with 99.995% pure N_2 (or “zero grade”) at a flow rate of 1.0 liters/minute.

3.5 Special Ground Support Equipment (GSE)

3.5.1 Mechanical GSE

The EUV instrument shall contain optical equipment for positioning the EUV bracket on the payload deck plate. This equipment shall include a boresight mirror and a mirror to establish rotational alignment about the optic axis of sensor 1. The EUV team may supply a light stimulus for vacuum testing.

3.5.2 Electrical GSE

EUV will interface with the EGSE. The EGSE shall contain a computer with port to emulate CIDP, including roll phase pulses on the sync line (0.1° pulses, nadir marker, Sun marker.) and power supplies. The computer shall record and display images, pulse height distributions, housekeeping data, etc. There shall be a substitute for the HV safing plug.

3.6 Operations Support and Training

3.7 Special Considerations

The detector high voltage may not be turned on unless the sensor heads have been at a pressure of less than 5×10^{-6} torr for 4 hours or more.

4. VERIFICATION

4.1 General

All instrument-level verification activities for the EUV program will be the responsibility of Southwest Research Institute or The University of Arizona as determined by SwRI. Instrument level verification activities will take place at SwRI or at The University of Arizona.

All payload-level verification activities will be the responsibility of Southwest Research Institute. Payload-level verification activities will take place at SwRI.

4.1.1 Relationship to Management Reviews

4.1.1.1 Relationship to Design Reviews

Verification activities start during the functional testing of engineering units, before CDR.

4.1.1.2 Verification Accomplishment

Verification will be reviewed at Instrument CDR, at Mission CDR, at instrument pre-ship review, and at S/C pre-ship review.

4.1.2 Test/Equipment Failure

Test procedures shall specify requirements for test equipment calibration. Should test equipment fail during the performance of a test, the test shall be halted. A Nonconformance Report describing the nature of the failure and requirements for failure analysis shall be prepared. The failure analysis shall address these issues:

- Status of the test procedure - whether to continue from the point of test equipment failure or to restart the test from beginning. This determination shall be based upon whether the test equipment failure has the potential to compromise the test results gathered prior to the failure.
- Whether, for purposes of this test, to repair or replace the failed test equipment. If the test equipment is repaired, identify any actions that need to be taken to restore confidence in the integrity of the test equipment.

4.2 Verification Method Selection

The default verification method of choice is test. Only those activities which cannot be verified by test or present a danger of damage to the instrument hardware will be performed by demonstration, analysis, inspection, or similarity assessment.

4.2.1 Test

A test provides a quantitative method to verify conformance of functional characteristics with specified requirements. The object being tested performs its required functions as a test engineer monitors and analyzes its performance to ensure it meets specified performance levels. A test is associated with specific pass or fail criteria; a test is successful when the criteria are met (i.e., acceptance criteria). Test is generally used to verify performance or functional requirements that can be measured using precision equipment.

4.2.2 Demonstration

A demonstration is a functional qualitative (test) verification method that evaluates functional characteristics without the need to evaluate detailed design performance. A demonstration is generally used to verify functional requirements and generally does not require precision test equipment.

4.2.3 Analysis

An analysis is an engineering assessment or mathematical verification method that uses techniques and tools such as math models, prior test data, simulations, or analytical assessments to confirm compliance with specification requirements with appropriate margin. Whenever possible, test data are used to validate the analytical techniques use for verification. Analysis is mainly used to verify performance where a test is not practical or feasible. Analysis also includes processing accumulated data, including data from lower levels and other verification methods, to conclude that a complex, integrated system meets its top-level performance requirements.

4.2.4 Inspection

Inspection is a verification method in which examination or measurement of product characteristics or the review of design, production, or test documentation determines compliance with specification requirements. Inspection of design, production, or test documentation involves engineering review and buyoff and is not performed against test procedures. Inspections are nondestructive and consist of visual observation or simple measurement.

4.3 Phased Verification Requirements

4.3.1 Instrument Development, Qualification, and Acceptance

The verification activities executed during instrument development and under the aegis of the instrument developer are shown in the “I” column of Table 4-1.

4.3.2 Payload Integration/Testing

The verification activities executed during payload integration and testing and under the aegis of Southwest Research Institute are shown in the “P” column of Table 4-1.

4.3.3 Observatory Integration/Testing

The verification activities executed during spacecraft to payload integration and during observatory testing and under the aegis of LMMS are shown in the “O” column of Table 4-1.

4.3.4 Flight/Mission Operations

No verification will be necessary during Flight/Mission operations. Some calibration activities will be conducted on orbit, and tests of system operations such as the sun-warning pulse from the CIDP may be carried out, but primary verification that all specifications are met will be prior to launch.

4.4 Verification Cross Reference Index

Table 4-1 contains the verification matrix used to identify the level and method of requirement verification defined in this specification. The codes used as required for delineating the verification matrix, are as follows:

Method:			Level:
T	=	Test (4.2.1)	I = Instrument Level (4.3.1)
D	=	Demonstration (4.2.2)	P = Payload Integration Level (4.3.2)
A	=	Analysis (4.2.3)	O = Observatory Level (4.3.3)
I	=	Inspection (4.2.4)	C = Component Level
S	=	Similarity Assessment (4.2.5)	

Table 4-1: EUV Verification Matrix

Requirement	**C**	**I**	**P**	**O**
3.1 Functional Requirements				
3.2 Performance Requirements				
3.2.1 Sensor Head				
3.2.1.1 General Description		I	I	
3.2.1.2 Spatial Resolution	T	T		
3.2.1.3 Wavelength	T	T		
3.2.1.4 Imaging Frequency		T	T	
3.2.1.5 Sensitivity	T	T		
3.2.1.6 Field of View	T	T		
3.2.2 Electronics Module				
3.2.2.1 Memory	T	T	T	
3.2.2.2 Communications to Sensor Head		T	T	T
3.2.2.3 Processor Throughput	T	T	T	
3.2.2.4 HVPS Control	T	T	T	T
3.2.2.5 Data Collection Requirements		T	T	T
3.2.2.6 Controller Embedded Software				
3.2.2.6.1 General Description	I	I		
3.2.2.6.2 Software Configurations	I	I		
3.2.2.6.3 Operational Sequence and Characteristics	T	T	T	T
3.2.3 Power Supply Module				
3.2.3.1 Supply to Sensor Head	T	T		
3.2.3.2 Supply to Electronics Module	T	T		

Requirement	**C**	**I**	**P**	**O**
3.2.3.3 Safe-mode Performance	T	T		T
3.2.3.4 Transient (Turn-on and Turn-off) Performance	T	T		
3.3 Interfaces				
3.3.1 Mechanical				
3.3.1.1 Mechanical Dimensions	I	D	D	D
3.3.1.2 Mass Properties	T	T		
3.3.1.3 Instrument Center of Mass		A	T	
3.3.1.4 Radiation Design	A			
3.3.1.5 Deployables	N/A	N/A	N/A	N/A
3.3.1.6 Clear Field-of-View			I	I
3.3.1.7 Alignment		T	A	A,T
3.3.1.8 Handling		D	D	D
3.3.1.9 Remove-Before-Flight Items			I	I
3.3.2 Electrical				
3.3.2.1 Power	A,T	T		T
3.3.2.2 Power Profile and Peak Power	A,T	T		T
3.3.2.4 Cables		D	D	
3.3.2.5 Connectors		D	D	
3.3.2.6 Grounding	I	I		
3.3.2.7 Safety Connectors	T	T	T	T
3.3.2.10 Timing Requirements	T	T	T	T
3.3.3 Command and Data Handling				

Requirement	**C**	**I**	**P**	**O**
3.3.3.1 Power On/Off Commands	T	T	T	T
3.3.3.2 Memory Load Commands	T	T	T	T
3.3.3.3 Serial Digital Data	T	T	T	T
3.3.3.4 Health and Safety	A	A	A	A
3.3.4 Central Instrument Data Processor				
3.3.4.1 Data Transfer Rate		T	T	T
3.3.4.2 CIDP Processing Requirements		A	T	T
3.3.4.3 Processing Rate		T	T	
3.3.4.4 Uncompressed Data Storage Requirements		A	A	A
3.3.4.5 Instrument Control Functions	T	T	T	T
3.3.4.6 Instrument Safe Requirements		T	T	T
3.3.4.7 Preferred Protocol for Serial Interface		I		
3.3.5 Thermal				
3.3.5.1 Thermal Design Requirements		T,A		T
3.3.5.2 Thermal Design Concept		I		
3.3.5.3 Thermal Interfaces		A		
3.3.5.5 Thermal Finish	I			
3.3.5.6 Temperature Range		T		T
3.3.5.7 Temperature Monitoring	T	T	T	T
3.3.5.8 Thermal Analysis and Predictions		A		
3.4 Other Design Requirements				
3.4.1 Environments	T	T		T

Requirement	C	I	P	O
3.4.2 Life		A		
3.4.3 Reliability		A		
3.4.4 Maintainability and Storage		D		
3.4.5 Safety				
3.4.5.1 Transportation Safety		I		
3.4.5.2 GSE Safety		I		
3.4.6 Special Materials & Processes Constraints				
3.4.6.1 Sensitive Components		I		
3.4.6.2 Limits		I	I	I
3.4.6.3 Protection		I	I	I
3.4.6.4 Purge Connector		I	I	
3.4.6.5 Purging		T	A	D
3.5 Special Ground Support Equipment (GSE)				
3.5.1 Mechanical GSE	D	D	D	
3.5.2 Electrical GSE	D	D	D	
3.6 Operations Support and Training	N/A	N/A	N/A	N/A
3.7 Special Considerations		D	D	D

4.5 Test Support Requirements

4.5.1 Facilities and Equipment

SwRI is responsible for all payload-level verification testing. Observatory-level verification activities will be carried out at LMMS by SwRI and LMMS jointly, with participation as needed by the instrument teams. Some NASA facilities may be used by instrument teams for instrument-level verifications.

4.5.1.1 Utilization of Existing Facilities and Equipment

During test flow, EUV will require access to SwRI vibration, thermal, and thermal vacuum facilities.

4.5.1.2 Establishment of Activation and Operations Plans

Test flow and operations for EUV will be described in detail in the EUV Acceptance Procedure. The test procedure will provide a check off for every step during the test flow. Before any major test operation, personnel will be briefed as to the intent of the test and any special procedures that must be performed. The test plan will provide procedures for handling anomalous conditions.

4.5.1.3 Qualification/Certification of Test Equipment

During the preparation of verification test procedures attention is given to the safety of the test article. Procedures designed for use with critical end-item hardware always require verification of the safety of the test equipment used in the test. In most cases this involves an independent measurement of interface conditions with the equipment disconnected from the end-item. Precautions are taken to insure that overvoltage conditions from a failed item of test equipment cannot stress the interface to the end-item. All test equipment requires calibration prior to use in verification testing, another step which helps reduce the possibility of improper operation. Finally, test personnel are briefed on the use of test equipment and on the flow of activities in a pre-test briefing preceding all verification tests.

4.5.2 Articles

None

4.5.3 Interfaces

EUV interfaces with an EGSE unit to provide services similar to the CIDP during testing. EUV's performance is verified by viewing a source of EUV and FUV photons using the UV Calibration Facility at the University of Arizona. During payload testing and later, EUV will interface with the CIDP, payload deck, and S/C in its flight configuration.

5. PREPARATION FOR DELIVERY

5.1 Final Assembly Site

Initial Integration of the EUV Imager with the science payload components will be performed at Southwest Research Institute in San Antonio, Texas.

Final Integration will be at Lockheed-Martin Missiles & Space, Sunnyvale, California.

5.2 Transportation

5.2.1 Transportation Modes

Cross country transportation will be provided by an environment controlled trailer/transporter which is compatible with the environmental conditioning requirements specified in Section 3.4.6. Ground transportation to and from any location will be over paved surface roadways and ramps.

5.2.2 Transport Environment

During transport, an environmental enclosure shall be in place around the Spacecraft/Observatory. During all transportation operations the EUV Imager shall be maintained between -50C and +60C. Humidity shall be controlled by the hermetically sealed shipping container. Impact loads in all 3 S/C axes shall be as specified in Sect. 3.6.1.2 of the Spacecraft to Payload ICD. Temperature and humidity at the Spacecraft/Observatory and impact loads to the Spacecraft/Observatory shall be recorded from the time the Spacecraft/Observatory leaves the final assembly site to the time it arrives at the launch pad.

When the EUV is shipped separately from the payload, it shall be transported in the EUV shipping container, under continuous purge per section 3.4.6.4. The aperture cover shall be in place. The temperature and shock limits of the previous paragraph apply.

6. NOTES

6.1 Intended Use

The intended use of this specification is to document and disseminate Level 2 instrument design and verification requirements for the EUV Imager.

6.2 Meaning of Specific Words

Specific meanings are assigned to the use of words “shall”, should”, “is”, and “will” as follows:

6.2.1 Shall

“Shall” indicates a requirement to provide a function. “Shall” indicates that the requirement is mandatory and will be the subject of specific acceptance testing and compliance verification.

6.2.2 Should

“Should” indicates a desired goal for which there is no objective test. “Should” indicates that there will be an attempt to achieve the desired goal to the maximum extent feasible while remaining cost effective. Component or performance specified by statements using “should” may be subject to specific acceptance testing, but to only qualitatively assess the level of goal achievement against a specific set of test criteria.

6.2.3 Is or Will

“Is” or “will” indicate a statement of fact or provides information. Components or performance levels described by statements using “is” or “will” must not, by definition, refer to a goal or requirement.