020499-HESSI-005

HSI_SYS_033A

High Energy Solar Spectroscopic Imager (HESSI)

Missile System Pre-Launch Safety Package (MSPSP)

Rough Draft

26 February 1999

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HESSI ABBREVIATIONS AND ACRONYMS

AC	**Air Conditioning**
ACS	Attitude Control System
Al	Aluminum
BCC	**Battery Conditioning Console**
BOS	Bright Object Sensor
^oC	**Degrees Centigrade**
C&DH	Command and Data Handling
CCB	Charge Control Board
CCD	Charge Coupled Device
CEU	Central Electronics Unit
cfm	Cubic Feet per Minute
CIB	Communications Interface Board
CSS	Coarse Sun-Sensor
dbA	**Decibel**
DC	Direct Current
DCM	Data Control Module
DOT	Department of Transportation
EGSE	**Electrical Ground Support Equipment**
ESS	Essential Bus
ETR	Eastern Test Range
EWR	Eastern and Western Range
FEDS	**Front End Data System**
FES	Fine Error Sensors
FOV	Field of View
FPA	Focal Plane Assembly
Ft	Foot
GN_2	**Gaseous Nitrogen**
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HESSI	**High Energy Solar Spectroscopic Imager**
HRI	Hazard Risk Index
Hz	Hertz
I&T	**Integration and Test**
IDPU	Instrument Data Processing Unit
in	Inch

I/O	Input/Output
IPA	Isopropyl Alcohol
ITOS	Integrated Test and Operations System
kg	**Kilogram**
KSC	Kennedy Space Center
lb	**Pound**
Lbs	Pounds
LEO-T	Low Earth Orbiter Terminal
LN2	Liquid Nitrogen
Mbyte	**Mega Byte**
MDP	Maximum Design Pressure
MEOP	Maximum Expected Operating Pressure
mg	Milligram
MGSE	Mechanical Ground Support Equipment
ml	Milliliter
MLI	Multi-Layer Insulation
MS	Margin of Safety
MSDS	Material Safety Data Sheet
MSPSP	Missile System Pre-launch Safety Package
MTB	Magnetic Torquer Bars
NASA	**National Aeronautics and Space Administration**
NEA	Non-Explosive Actuator
NESS	Non-Essential Bus
NiCd	Nickel-Cadmium
O2	**Oxygen**
Orbital	Orbital Sciences Corporation
P/L	**Payload**
PACI	Payload and Attitude Control Interface
PAF	Payload Attach Fitting
PCB	Power Control Board
PDM	Power Distribution Module
PHA	Preliminary Hazard Analysis
PPE	Personal Protection Equipment
PSE	Power System Electronics
psi	Pounds per Square Inch
psig	Pounds per Square Inch Guage
PSIU	Power Source Interface Unit
PSM	Power Switching Module

RF	**Radio Frequency**
RFCU	Radio Frequency Control Unit
RH	Relative Humidity
rms	Root Mean Square
Rpm	Round per Minute
S/A	**Solar Array**
S/C	Spacecraft
SELVS	Small Expendable Launch Vehicle System
SCAT	Spacecraft Command and Telemetry
SMA	Shaped Memory Alloy
SPF	Single Point Failure
SPM	Signal Processing Module
TX	**Transmitter**
UCB	**University of California at Berkeley**
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
V	**Volts**
VDC	Volts DC
W	**Watt**
WIRE	Wide-Field Infrared Explorer
WR	Western Range

1.0 INTRODUCTION

The High Energy Solar Spectroscopic Imager (HESSI) is a NASA-supported Small Explorer mission to be launched in July 2000, to explore the sun's solar flares. The HESSI team consists of the University of California at Berkeley (UCB), the Goddard Space Flight Center (GSFC), Spectrum Astro, and Paul Scherrer Institute (PSI).

The HESSI project is a collaboration between domestic universities and industry, international partners, and the National Aeronautics and Space Administration (NASA). The University of California at Berkeley is responsible for the development of the entire mission including the mission scientific oversight. UCB will direct the efforts of the development team.

1.1 PURPOSE

This Missile System Prelaunch Safety Package (MSPSP) provides an assessment of the risks assumed during design, integration transportation, handling, integration, and launch of the HESSI Spacecraft. This MSPSP documents identified hazards and provides the initial assessment of the hazards. This Document also identifies design changes, safety devices, warning devices, or procedural controls to be imposed on system elements to eliminate or control hazards that could cause injury to personnel or damage to equipment.

1.2 SCOPE

This MSPSP documents HESSI satellite compliance with the requirements established by the Eastern and Western Range Regulations, EWR 127-1 dated 31 October 1997 as tailored for HESSI. This MSPSP also identifies and discusses any non-compliant items, ground support equipment (GSE), launch vehicle interfaces, and pre-launch operations at Kennedy Space Center (KSC) and Vandenberg Air Force Base (VAFB). This document also serves to demonstrate that requirements and procedures are met to obtain flight and ground payload safety approval.

1.3 APPLICABLE DOCUMENTS

Listed below are applicable safety-related documents and guidelines used for HESSI design, testing, processing, and operations :

EWR 127-1	Eastern and Western Range Regulations for Range Safety, October 1997.
GHB 1860.2	Radiation Safety Handbook
MIL-STD-461B	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interface.

MIL-STD-882C	System Safety Program Requirements.
MIL-STD-1522A	Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems
MIL-STD-1553	DoD Interface Standard for Digital Time Division Command/Response Multiplex Data Bus
NHB 1700.1	NASA Safety Policy and Requirements Document
NSS/GO-174.9	Design Inspection and Certification of Lifting Devices and Equipment
SSD TD-0018	Pegasus Requirements Document for Ground Operations
SSD TD-0005	Pegasus Design Safety Requirements Document

2.0 GENERAL SYSTEMS DESCRIPTION

HESSI is managed by the University of California at Berkeley and will be launched on a Pegasus XL Small Expendable Launch Vehicle Service (SELVS) II via an L1011. The HESSI Mission involves a single instrument consisting of an Imaging System, a Spectrometer, and Instrument Electronics, mounted in a simple Sun-pointed, spin-stabilized spacecraft.

2.0.1 Mission

HESSI will be launched into an 600-km circular orbit for a three-year mission, with a total satellite mass to orbit of 299.5 kg. The core of the HESSI mission is high resolution spectroscopic imaging of solar flares. Science and mission operations will be located at UCB.

2.1 SPACECRAFT

The HESSI Spacecraft Bus is based on a Small Explorer platform and is designed for compatibility with the Pegasus XL Launch Vehicle. The spacecraft bus will be built by Spectrum Astro and will supply power, orientation control, communications, and data storage for the HESSI instrument. The spacecraft bus weighs approximately 150 kg. The bus and instrument weigh approximately 300 kg. Figure 2-1 is a plan view of the Spacecraft Bus. Figure 2-2 shows the Spacecraft Bus Equipment Deck.

The spacecraft consists of the mechanical subsystem (primary structure and deployable mechanisms), command and data handling subsystem, attitude control subsystem, power subsystem, RF communications subsystem, and thermal control subsystem. Power is generated for both the spacecraft and instrument by four deployable solar array panels that charge the spacecraft's Nickel-Hydrogen (NiH_2) battery.

2.1.1 Structure

The primary structure is composed of a single aluminum honeycomb panel and a thrust tube to carry loads from the launch vehicle adapter ring. The open structural design permits thermal radiator area for heat rejection and enables access to spacecraft and instrument components throughout all phases of integration and test to reduce cost and schedule. All spacecraft components are attached to the mid-deck panel allowing the spectrometer to have an unobstructed radial field-of-view. The spectrometer and the imager assembly are structurally independent from one another, allowing separate bolt-on installation – the imager assembly is installed from above the mid-deck and the spectrometer is installed from below.

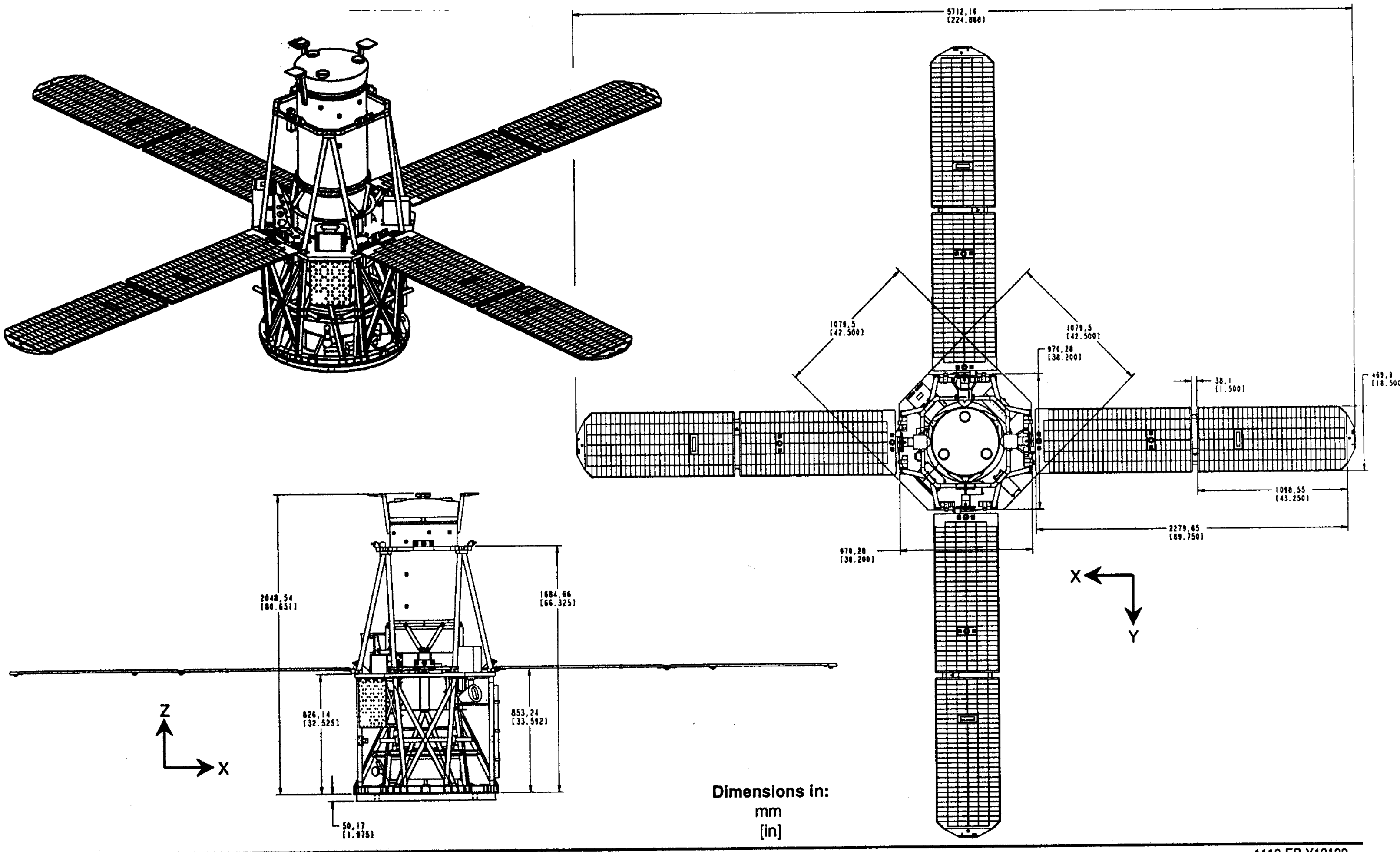

Figure 2-1 Plan View of Spacecraft Bus

SYSTEMS ENGINEERING
SPACECRAFT BUS EQUIPMENT DECK

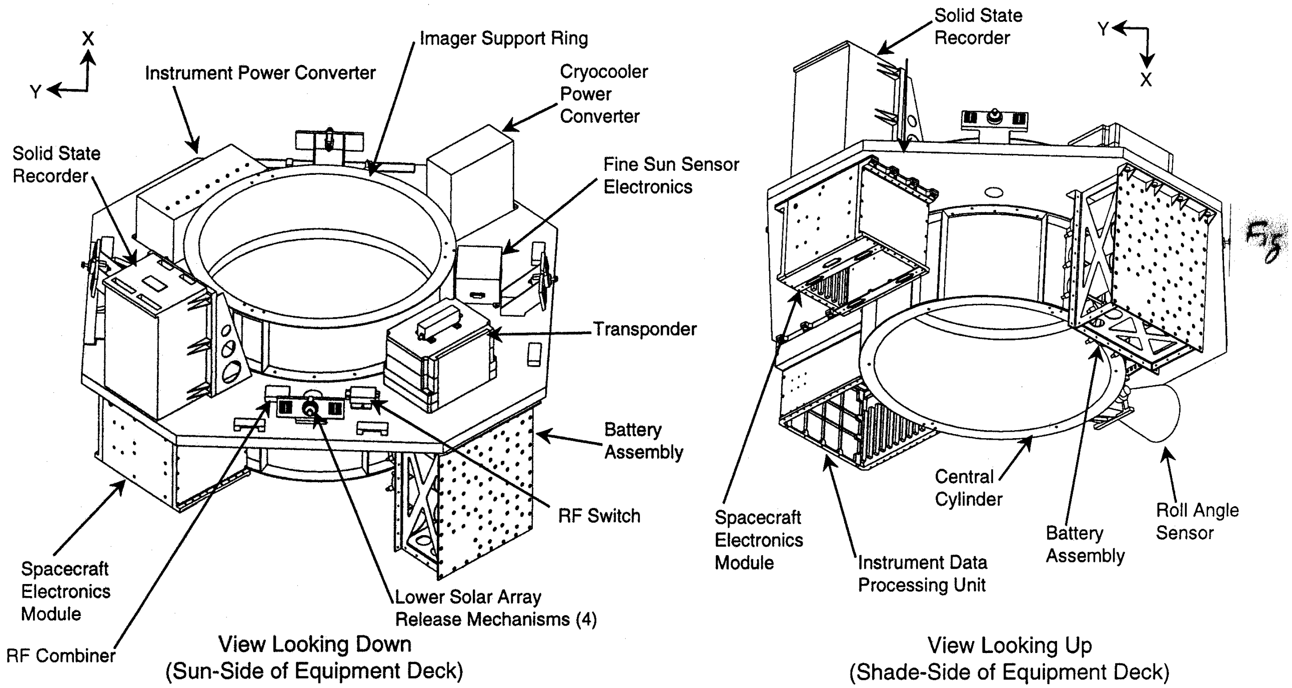

Figure 2-2 Spacecraft Bus Equipment Deck

2.2 INSTRUMENT

The HESSI Instrument, shown in Figure 2-3, consists of an Imaging System, a Spectrometer, and the Instrument Electronics. The Imaging System is made up of nine Rotating Modulation Collimators (RMCs), each consisting of a pair of widely separated grids mounted on a rotating spacecraft. Pointing information is provided by the Solar Aspect System (SAS) and Roll Angle System (RAS). The Spectrometer has nine segmented Germanium Detectors (GeDs), one behind each RMC, to detect photons from 3 keV to 20 MeV. The GeDs are cooled to <~75 K by a space-qualified long-life mechanical cryocooler. The Instrument Electronics amplify, shape, and digitize the GeD signals, provide low-voltage power and GeD high voltage, format the data, and interface to the spacecraft electronics. Essentially all of the HESSI instrument components have extensive flight or life-cycle heritage.

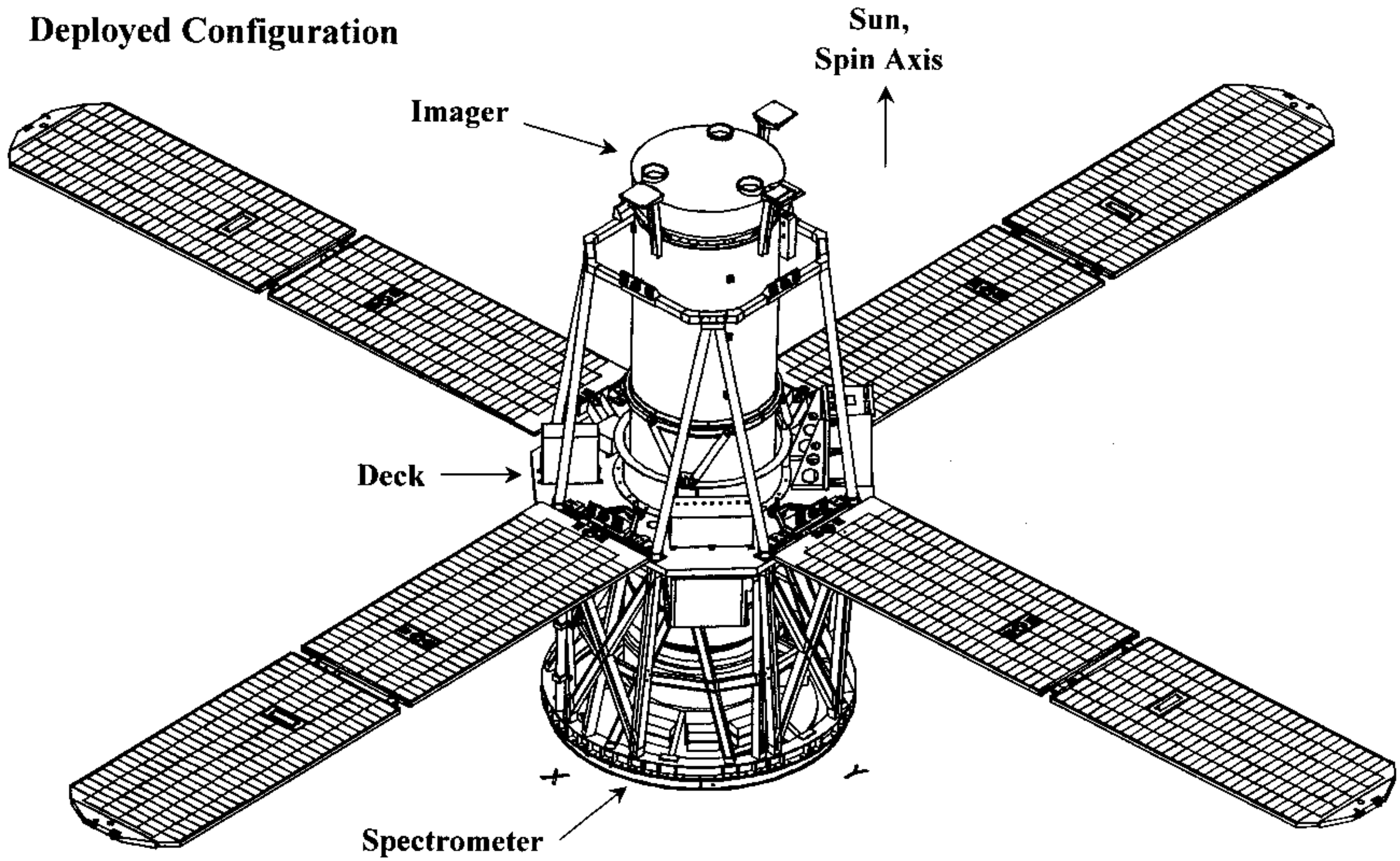

Figure 2-3 HESSI Instrument

3.0 FLIGHT HARDWARE SUBSYSTEMS

3.1 INSTRUMENT DESCRIPTIONS

3.1.1 General Description

The only instrument on board is an imaging spectrometer with the ability to obtain high fidelity color movies of solar flares in x-rays and gamma rays. The major elements of the instrument are an imager, a spectrometer and a cryostat. The instrument is shown in figure 3-1.

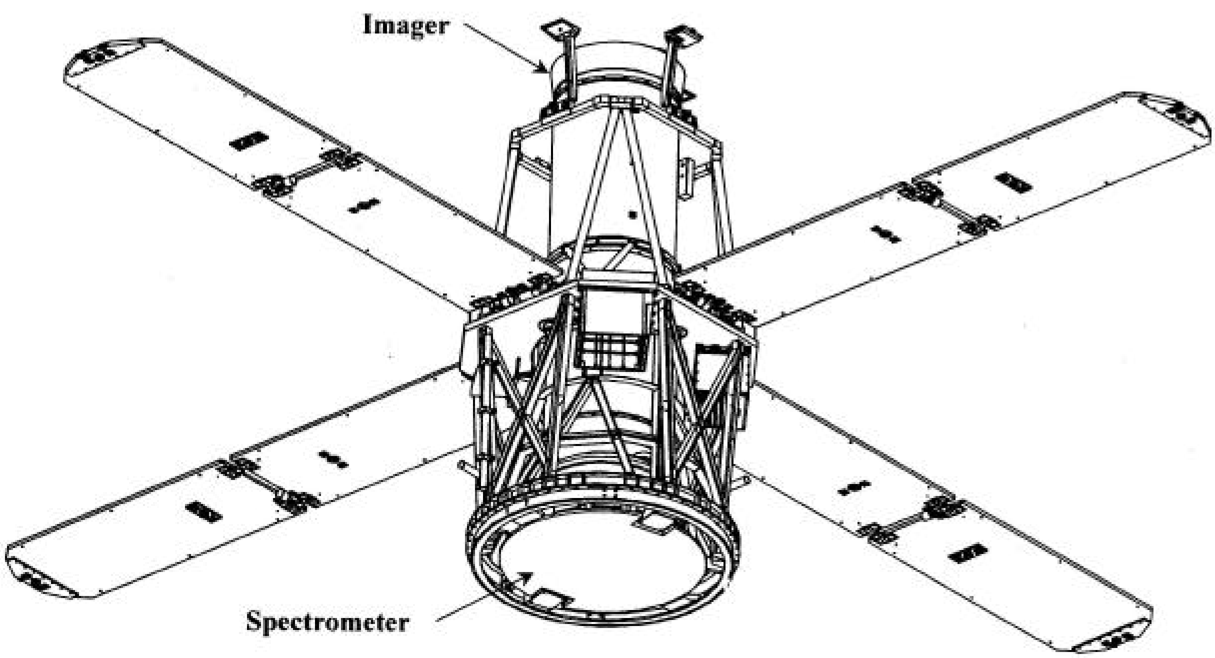

Figure 3-1: HESSI Instrument

3.1.1.1 Imager

The imaging capability of HESSI is based on a Fourier-transform technique using a set of 9 Rotational Modulation Collimators (RMC's). Each RMC consist of two widely-spaced fine-scale linear grids made of tungsten and/or gold, which temporally modulate the photon signal from sources in the field of view as the spacecraft rotates about an axis parallel to the long axis of the RMC. The imager is shown in Figure 3-2.

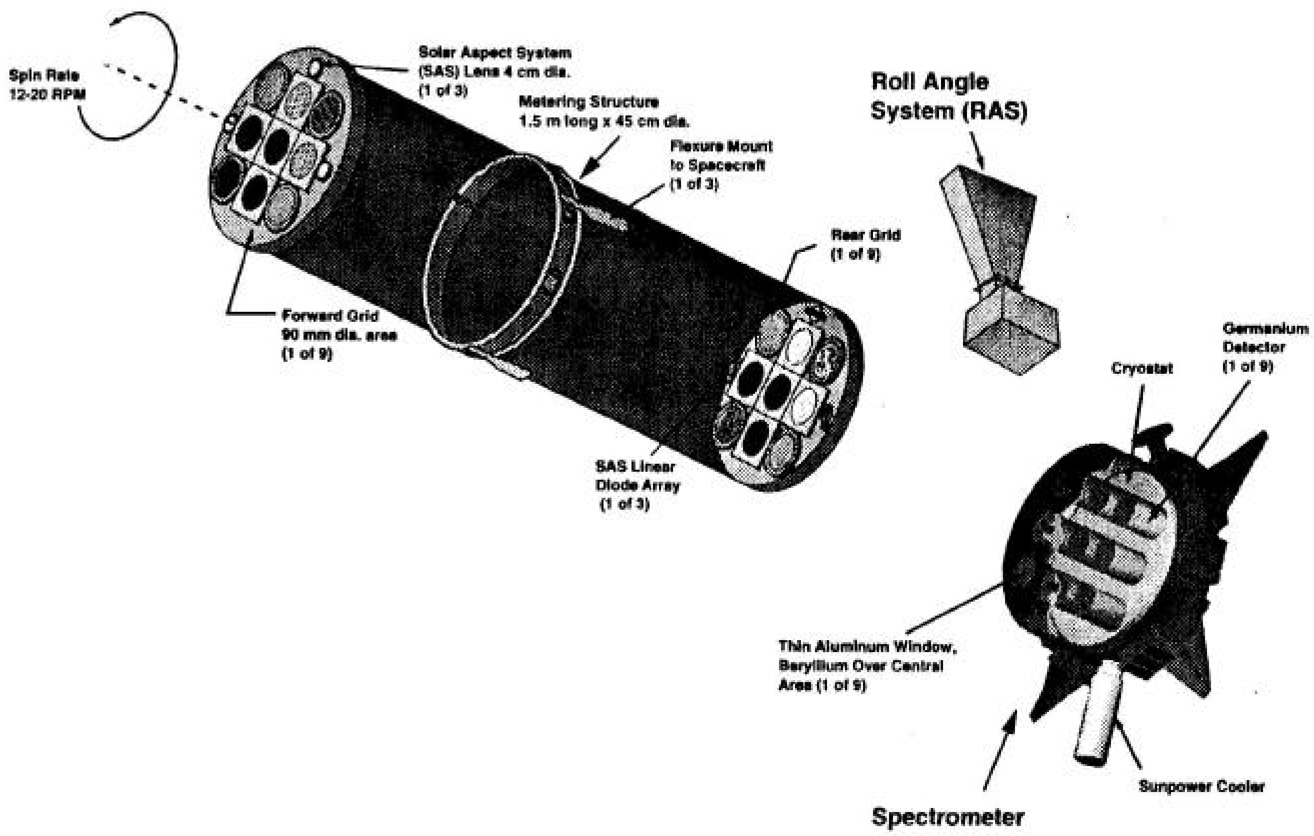

Figure 3-2: HESSI Imager

3.1.1.2 Spectrometer

The high-resolution spectroscopy is achieved with 9 cooled germanium crystals that detect the x-ray and gamma-ray photons transmitted through the grids over the broad energy range of 3 keV to 20 MeV. The spectrometer's detectors base lined for the HESSI behind the RMC's are the largest currently available hyper (n-type) germanium detectors (HPGe), 7.1cm in diameter and 8.5 cm long. They will be cooled to their operating temperature of 75 K by a single electro-mechanical cryocooler. The spectrometer with cryocooler is shown in Figure 3-3.

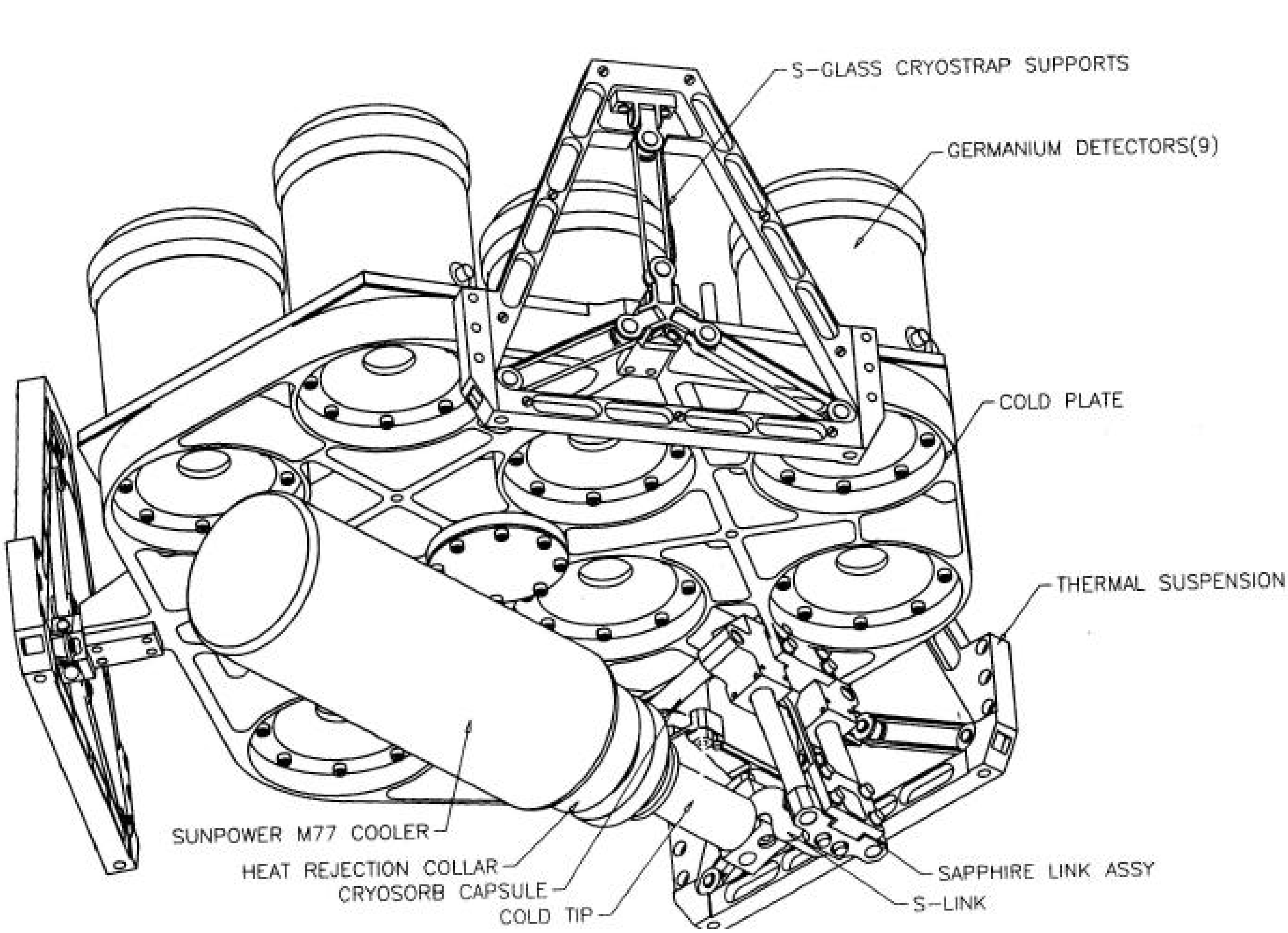

Figure 3-3: HESSI Spectrometer with Cryocooler

3.1.1.2.1 Cryocooler

The cryocooler is a commercially available Sunpower M77 Cooler and shown in Figure 3-4. The compact, 5kg cryocooler utilizes an integral, free piston Sterling configuration that operates with low vibration and is hermetically sealed to a leakage rate of less than 1x 10^8 standard cubic centimeters per second. The cryocooler has a helium working fluid with no CFC's or oil.

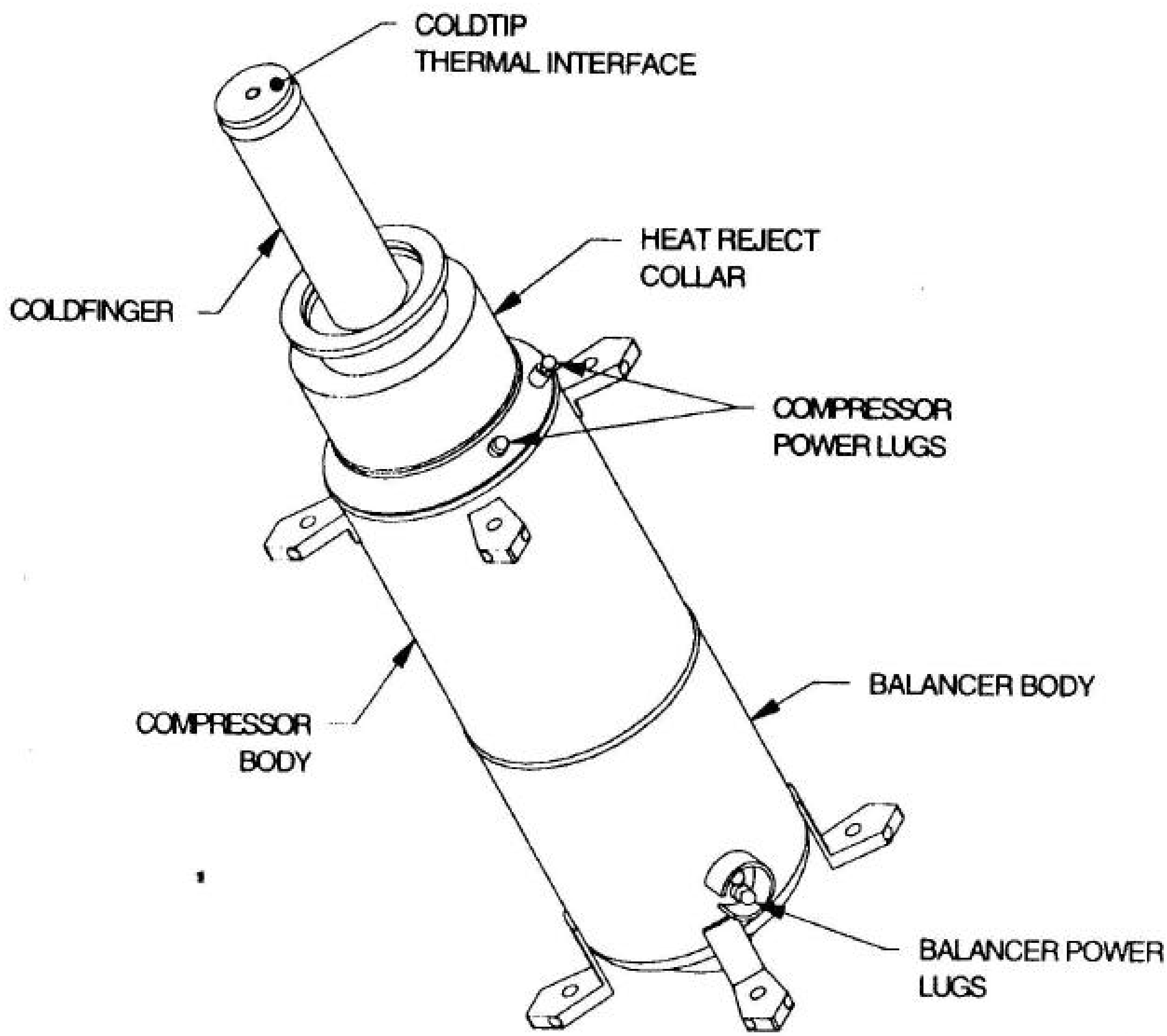

Figure 3-4: HESSI Sunpower M77 Cryocooler

3.1.1.3 Cryostat

The cryostat houses nine hyper-pure germanium detectors that are cooled to approximately 75°K. The cryostat has a 30" diameter, unrestricted view radiator to enhance cooler performance. The cryostat is shown in Figure 3-5.

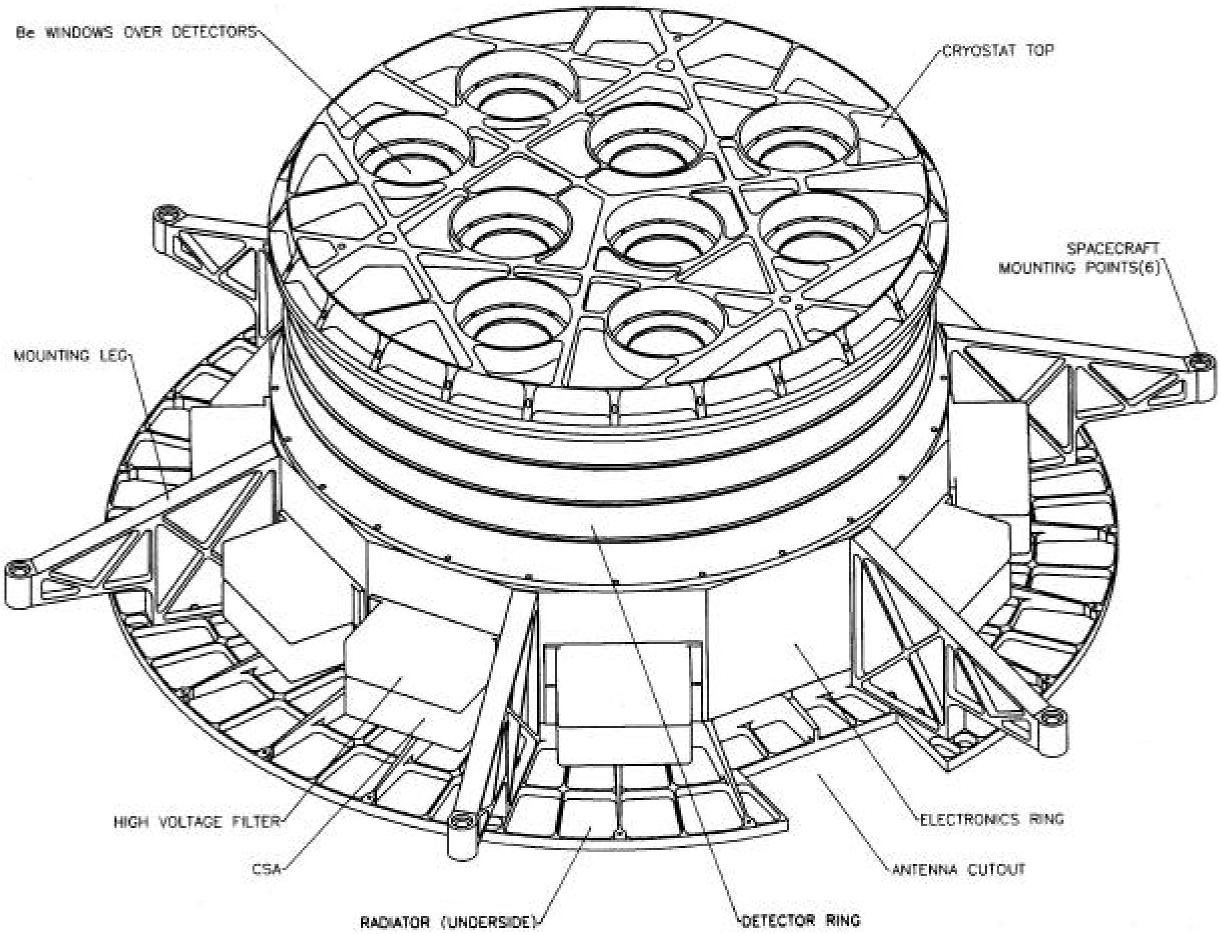

Figure 3-5: HESSI Cryostat

3.1.2 Structural/Mechanical Subsystems

The primary spacecraft structure is described in Section 3.2.2. The primary mechanisms on the instrument consist of the Cryocooler and Hi-Z Shutters.

3.1.2.1 Cryocooler

The cryocooler, described in Section 3.1.1.2.1, contains a free piston, linear motion, Helium gas compressor that is powered by the CPC and is actively controlled by the Instrument Data Processing Unit (IDPU). The residual operating forces will not exceed TBD (TBR-UCB-102) Newton's driven at 59 Hz.

3.1.2.2 Hi-Z Shutters

The Spectrometer includes two Hi-Z shutters. They are used to reduce the science data rate by blocking out low energy radiation during periods of high flux. The shutters are mounted on the top of the Spectrometer, with a center of mass at spacecraft station Z=11.3 inches, and near 0 in the X and Y axis. The moving mass is 300g Current Best Estimate (CBE) for the thick attenuator and 230g CBE for the thin attenuator. The thick attenuator is caged in the OUT position at launch, and activation of the shutter causes a motion of 60mm in the –Y direction in about 0.5 seconds. The thin shutter is caged in the IN position at launch, and activation causes a motion of 60mm in the +Y direction. The shutters are controlled to move in and out by the IDPU. The shutter layout in the caged configuration is shown in Figure 3-6.

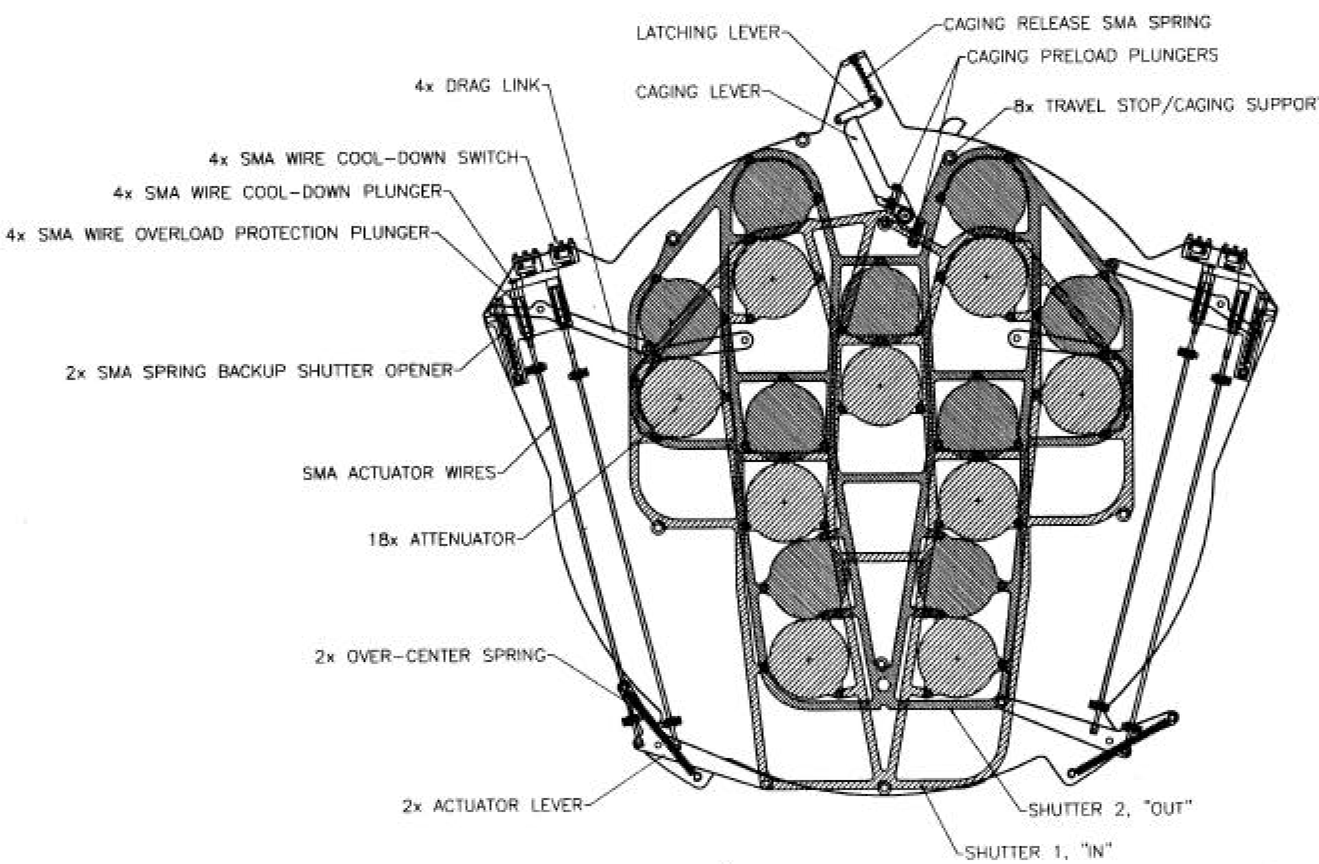

Figure 3-6: Shutter Layout in Caged Configuration

3.1.3 Pressure Subsystems

The pressure systems that are present on the HESSI Instrument include the Battery, described in Section 3.2.4.2, and the Cryostat. The cryostat is under a vacuum and is controlled by the Cryostat Vacuum Valve.

3.1.3.1 Cryostat Vacuum Valve

The cryostat includes a one shot vacuum valve to vent the cryostat to space after launch. This valve will be opened no sooner than several days after launch (nominally much later), and is controlled by the IDPU. A Shaped Memory Alloy (SMA) device opens the valve.

3.1.4 Electrical and Electronic Subsystems

TBD

3.1.4.1 Instrument Data Processing Unit (IDPU)

TBD

3.1.4.2 Grounding

TBD

3.1.5 Ordnance Subsystems

The HESSI Instrument does not contain any ordnance systems.

3.1.6 Non-Ionizing Radiation Subsystems

The only non-ionizing radiation sources within the instrument are TBD.

3.1.7 Ionizing Radiation Subsystems

The HESSI Instrument contains a small source of Cesium-137 used as a detector monitoring device. A detailed description of this source TBS.

3.1.8 Acoustical Subsystems

Currently no equipment, procedures or operations associated with or related to the HESSI instrument have been identified that are considered hazardous.

3.1.9 Thermal Control Subsystems

TBD

3.1.9.1 Spectrometer Thermal Control

The cryocooler provides up to four thermal watts of cooling using up to 100 watts of input electrical power. All of this power is ultimately radiated from the large bottom surface of the cryostat. Cooler operations controlled by the IDPU with feedback from temperature sensors in the Cryostat. Nominal and maximum power dissipation in the spectrometer is TBS.

The Spectrometer includes two heater circuits. The radiator heaters are initially used to bring the cryocooler up to acceptable startup temperatures. Coldplate heaters are also provided to control the cool-down and warm-up temperature distribution within the cryostat, and to allow on orbit annealing of the detectors. These heaters are controlled by the IDPU, and their power is TBS.

3.1.10 Hazardous Materials

See Section 6.4 for a detailed description of the hazardous materials associated with the HESSI Instrument.

3.2 SPACECRAFT DESCRIPTION

3.2.1 General Description

The HESSI Spacecraft Bus is based on a Small Explorer platform and is designed for compatibility with the Pegasus XL Launch Vehicle. The spacecraft bus will be built by Spectrum Astro and will supply power, orientation control, communications, and data storage for the HESSI instrument. The current best estimate for the mass of the spacecraft bus is 146.5 kg with the combined instrument mass of 299.5 kg. See Figure 3-7 for a dimensioned plan view of the Spacecraft Bus and Figure 3-8 for a view of the Spacecraft Bus Equipment Deck.

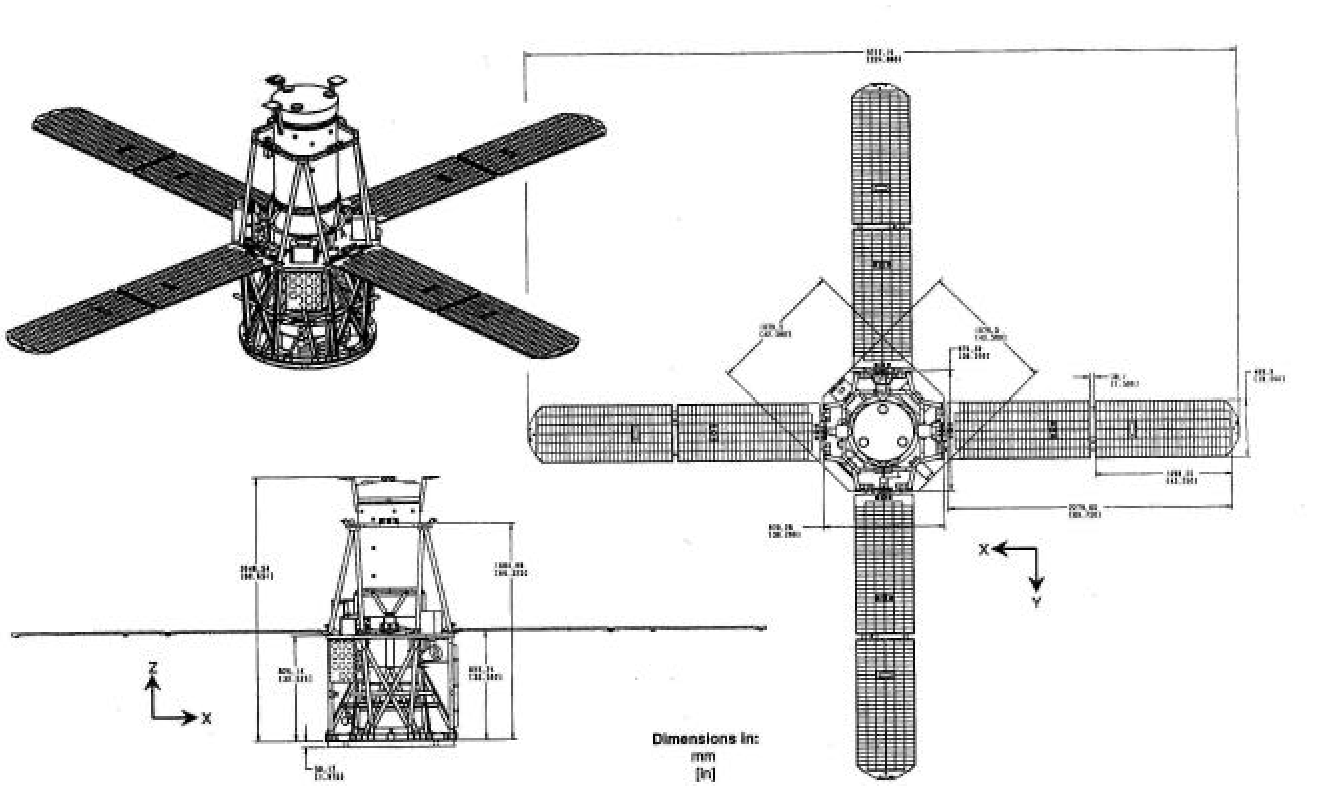

Figure 3-7: Hessi Spacecraft Bus

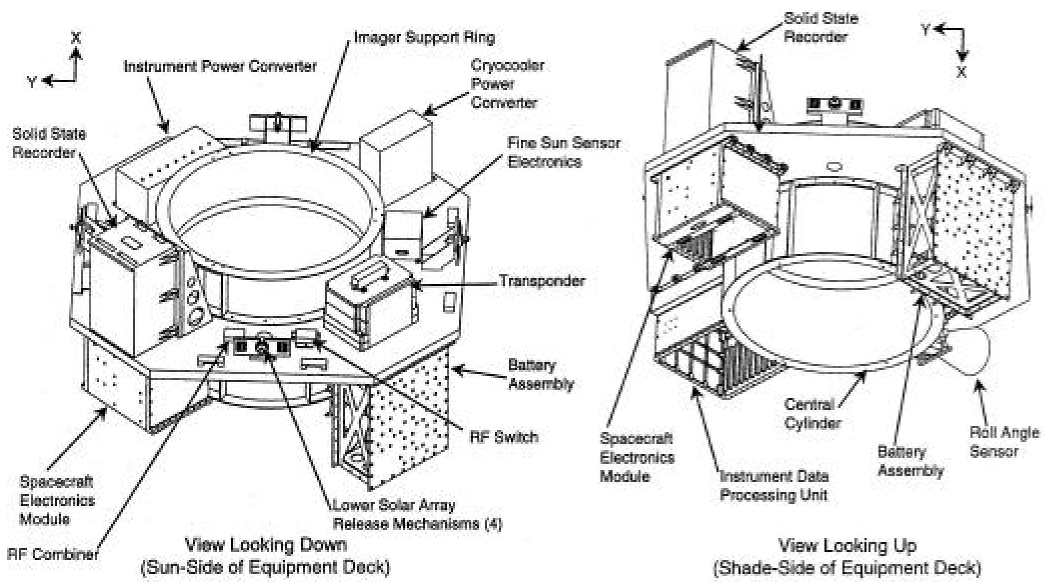

Figure 3-8: Spacecraft Bus Equipment Deck

3.2.2 Structural/Mechanical Subsystems

The mechanical subsystem consists of the primary spacecraft structure, secondary spacecraft structure, solar arrays and release mechanisms, and inertia adjustment device (See Figure 3-9 for a diagram of the spacecraft structure and mechanisms).

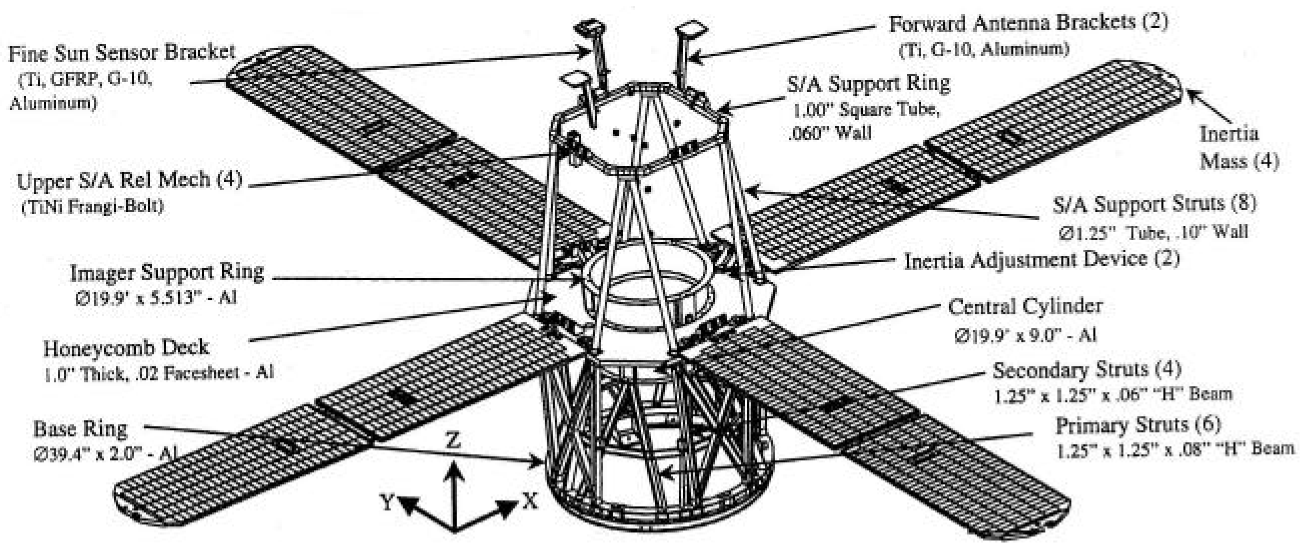

Figure 3-9: HESSI Spacecraft Structure and Mechanisms

3.2.2.1 Primary Spacecraft Structure

The primary structure is composed of a single aluminum honeycomb/aluminum face-sheet deck with an imager support ring, central cylinder, and strut system to provide a load path to the launch vehicle (Pegasus XL) adapter (See Figure 3-10). The open structural design permits thermal radiator area for heat rejection and enables access to spacecraft and instrument components throughout all phases of integration and test to reduce cost and schedule. All spacecraft components are attached to the mid-deck panel allowing the spectrometer to have an unobstructed radial field-of-view. The spectrometer and the imager assembly are structurally independent from one another, allowing separate bolt-on installation – the imager assembly is installed from above the mid-deck and the spectrometer is installed from below.

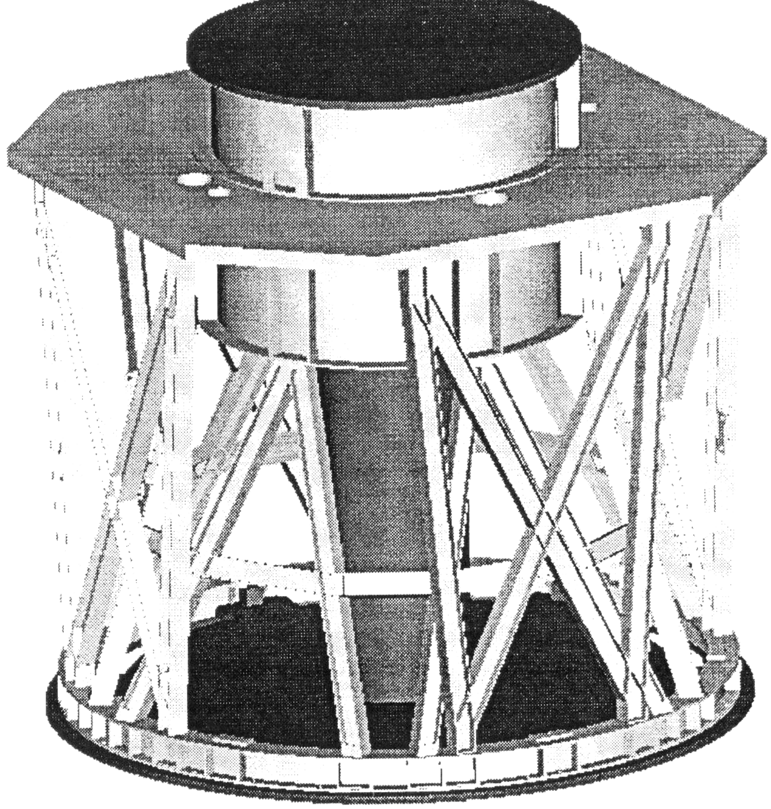

Figure 3-10: Primary Spacecraft Structure

Factors of safety for the structure are TBD for yield, and TBD for ultimate based on an analysis qualified structure. Margins of safety for the structure are provided in Table 3.2-1.

Table 3.2-1: Spacecraft Structure Margins of Safety

Component	Failure Mode	Margin
+Z Diagonal Mount Boss	Ultimate	+0.57
+Z Diagonal	Pin Bending	+1.12
+Z Diagonal	Beam column	+1.40
+Z Diagonal	Crippling	+1.90
+Z Frame	Buckling	+4.30
+Z Frame	Beam-Column	+1.06
+Z Frame	Crippling	+1.06
+Z Frame	Ultimate	+1.06
+Z Panel (½")	Ultimate	+HIGH
+Z Panel (½")	Shear Buckling	+HIGH
+Z Panel (½")	Intra-Cell Buckling	+HIGH
+Z Panel (½")	Face dimpling	+HIGH
1" Panels	Ultimate	+HIGH
1" Panels	Shear Buckling	+HIGH
1" Panels	Intra-Cell Buckling	+HIGH
1" Panels	Face Dimpling	+HIGH
-Z Frame	Buckling	+1.08
-Z Frame	Beam-Column	+2.13

Component	Failure Mode	Margin
-Z Frame	Crippling	+0.17
-Z Frame	Ultimate	+1.00
-Z Panel Stiffener Fasteners	Ultimate	+HIGH
-Z Panel Stiffener	Ultimate	+HIGH
+X & –X Longitudinals	Buckling	+HIGH
+X & –X Longitudinals	Beam-Column	+HIGH
+X & –X Longitudinals	Crippling	+HIGH
+X & –X Longitudinals	Ultimate	+2.10
Omni Boom	Ultimate	+0.18
Omni Boom Fasteners	Ultimate	+1.31
Main Diagonal Splice Fasteners	Ultimate	+0.29
Main diagonal	Buckling	+HIGH
Main diagonal	Beam-Column	+0.28
Main diagonal	Crippling	+HIGH
Main diagonal	Ultimate	+HIGH
+X Battery Panel	Local Stress	+2.9
Panel Edge Members	Ultimate	+0.64
Shear Panel/Frame I/F	Friction Slip	+0.29

3.2.2.2 Secondary Spacecraft Structure

The secondary spacecraft structure is composed mostly of the bracketry and interfaces needed for mounting the satellite hardware. The secondary structure consists of a solar array support ring, solar array support struts, solar array struts-to-deck fittings, magnetometer bracket, forward antenna bracket, fine sun sensor bracket, solid state recorder bracket, torque rod mounting bracket, aft antenna bracket, solar array mounting bracket, and dynamic balance mass.

3.2.2.3 Solar Arrays and Release Mechanisms

The solar array system utilizes four wings containing two panels per wing that measure 18.5" x 43.5" x .515" and are oriented along the X and Y axis (See Figure 3-11 for a labeled diagram of the solar array components). The mechanisms include two hinges per hinge line with a hinge line located in the mid-section between the two panels and another at the panel-to-spacecraft interface. Each hinge-line contains a damper to control the angular acceleration during panel deployment. The damper is supplied by DEB and has heritage with MightySat. The solar array release mechanism consists of a single shaped memory alloy (SMA) actuated release device, supplied byTiNi Alloy Company. HESSI contains no pyrotechnic devices instead the "Frangibolt" consists of an electric heater surrounding a hollow cylinder of TiNi and a specially notched bolt (See Figure 3-12). To deploy the payload, electric power heats the TiNi actuator cylinder; it expands and elongates the notched bolt to fracture. A cap to prevent projectile debris captivates the bolt head (See Figure 3-13 for a diagram of the solar array release mechanism). Factors of safety for the Solar Arrays are TBD for yield, and TBD for ultimate based on an analysis qualified structure. Margins of safety for the structure are provided in Table 3.2-2.

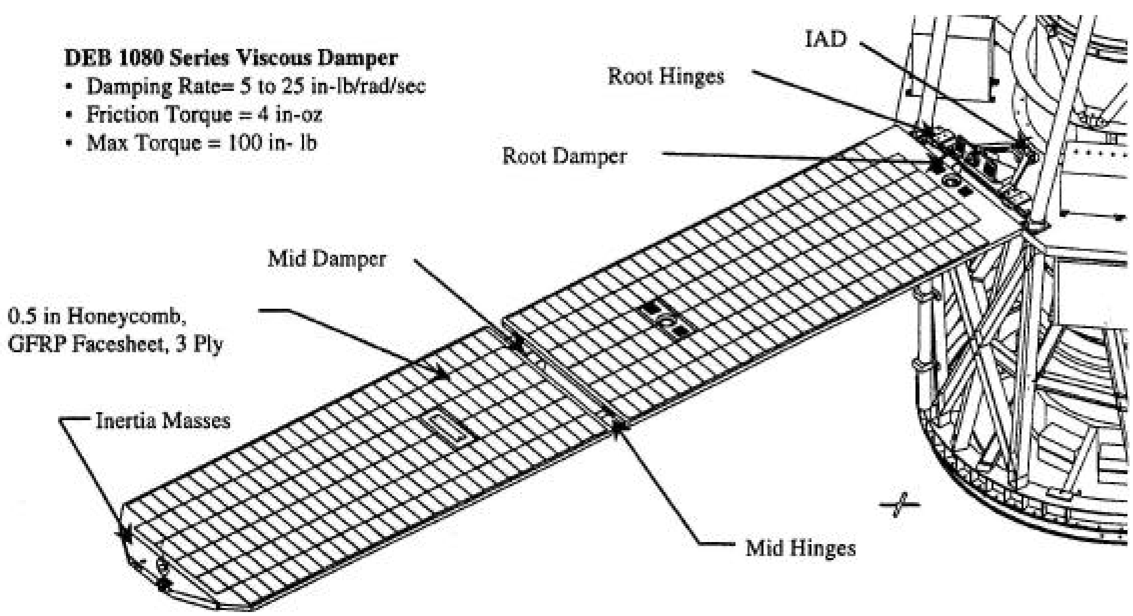

Figure 3-11: Solar Array Components

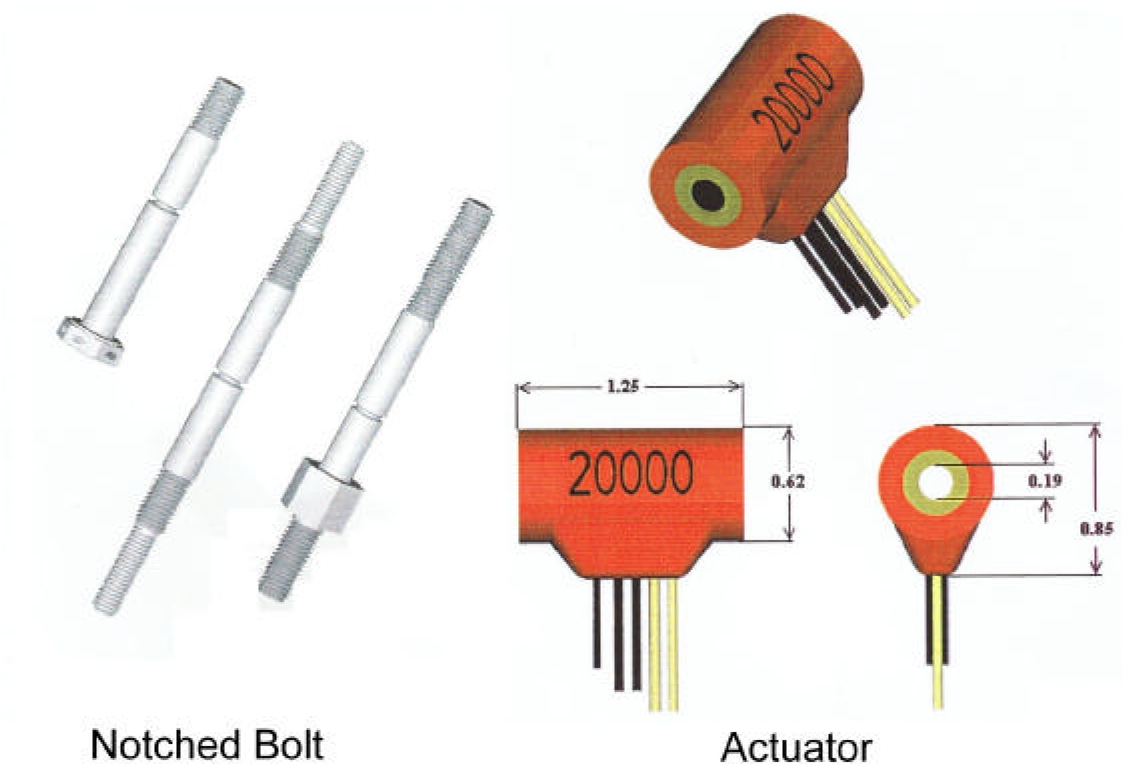

Figure 3-12: Solar Array Release Actuator with Notched Bolt

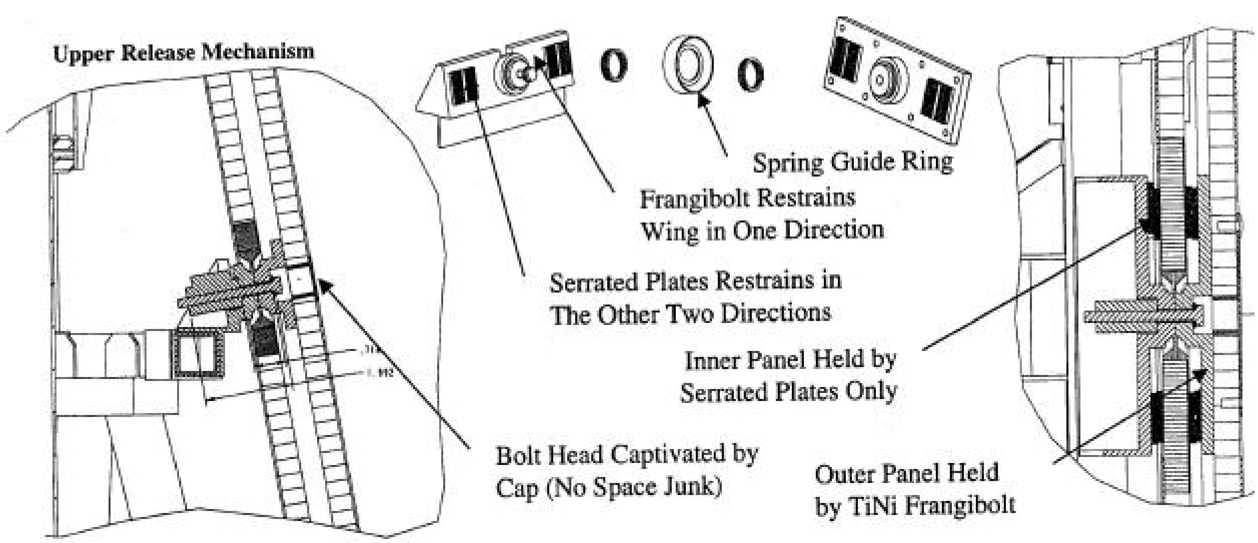

Figure 3-13: Solar Array Release Mechanism

Table 3.2-2: Solar Array Margins of Safety

Component	Failure Mode	Margin
Face Sheet Hinge Fasteners	Face Sheet Bearing	0.60
Face Sheet Hinge Fasteners	Net Tension	0.52
Face Sheet Hinge	Lamina Stress, Top	0.39
Face Sheet Hinge	Lamina Stress, Bottom	0.93
Face Sheet Hardpoint	Lamina Stress, Top	1.45
Face Sheet Hardpoint	Lamina Stress, Bottom	1.44
Face Sheet	Wrinkling	0.07
Face Sheet	Buckling	0.29
Face Sheet	Elastic Stability	1.14
Face Sheet	Buckling, 3 x 3 cell disbond	1.78
Face Sheet	Interlaminar Shear	+HIGH
Hex Core	Shear at Hinge	+HIGH
Hex Core	Shear at Hardpoint	2.50
Hex Core	Shear Stress	1.90
Hex Core	Shear Stability	+HIGH
Hex Core	Shear, Spool Splice	0.16
Sun Sensor Face Sheet	Lamina Stress	+HIGH
Spool	Adhesive Shear, Hardpoint	0.02
Spool	Bending, Hardpoint	1.14
Lift Inserts	Ground Handling, 5G	1.10

3.2.2.4 Inertia Adjustment Device (IAD)

Spacecraft dynamic balance is critically important to the operation of the instrument, and spacecraft components have been located with considerable attention paid to inertia properties. The dynamic balance of the spacecraft is controlled by the inertia adjustment device (IAD) (See Figure 3-14). The major components of the IAD are shown in Figures 3-15(a) thorough 3-15(c). In addition to the design efforts, the spacecraft will be spin-balanced following final system test, and linear mass drivers will be used on-orbit to do the fine adjustments that may be necessary following deployment of the solar array wings.

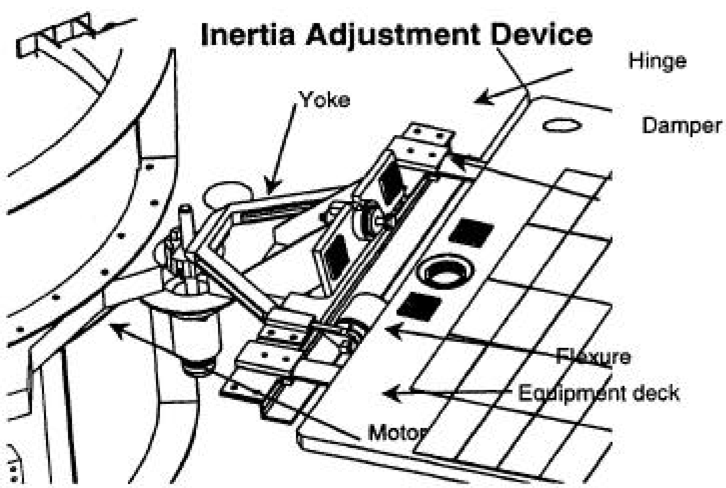

Figure 3-14: Inertia Adjustment Device (IAD)

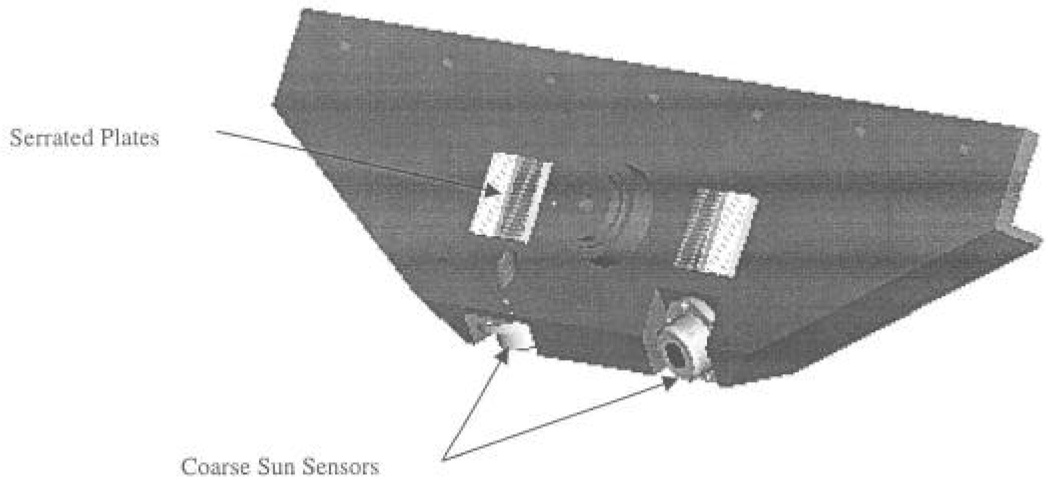

Figure 3-15(a)

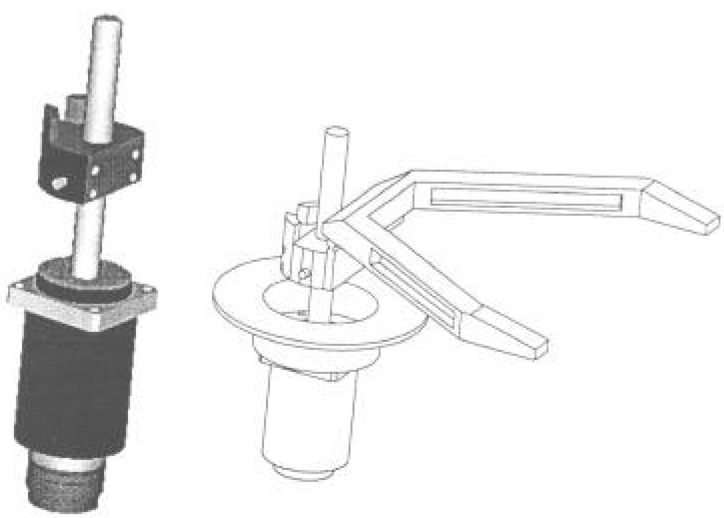

Figure 3-15(b)

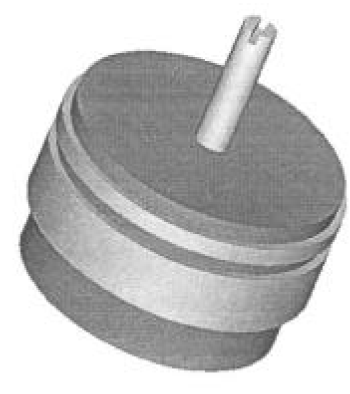

Figure 3-15(c)

IAD components

3.2.3 Pressure Subsystems

TBD

3.2.4 Electrical and Electronic Subsystems

The Electrical Power and Electronics subsystem consists of the four silicon-cell solar array wings, a single NiH_2 battery, a grounding subsystem, and all spacecraft cabling. Battery charging, power conversion and distribution are performed within the integrated electronics module (IEM) of the Command & Data Handling subsystem discussed in Section 3.2.5.

The IEM hosts the power input/output (PIO) board and the charge control board (CCB). The PIO, developed by Spectrum for Lunar Prospector, provides Versa Module Europe (VME)-controlled, 28 ±4 V switched power outputs. The CCB, also developed for Lunar Prospector, uses pulse-width modulated Field Effect Transistor (FET) switches to control the direct flow of array current to the battery.

3.2.4.1 Solar Array Wing

Each solar array wing consists of Al facesheet/Al honeycomb substrate with 2 ohm-cm; front surface passivated silicon cells and produces over 81 Watts at end of life for a total spacecraft power of 325 W. The cabling approach is based upon Spectrum's MightySat and New Millennium Program (NMP) DS-1 designs.

3.2.4.2 Battery

The HESSI battery subsystem consists of one Common Pressure Vessel (CPV) NiH_2 battery supplied by Eagle Picher. The battery stores power in eleven 15 amp-hour CPV cells, each under 1000psi and designed to leak-before-burst, connected in series to produce 28 ±4V and having a combined mass of 13.49 kg (See Figure 3-16). There will be a NiCd Workhorse battery used to minimize load to the flight battery and details are TBD.

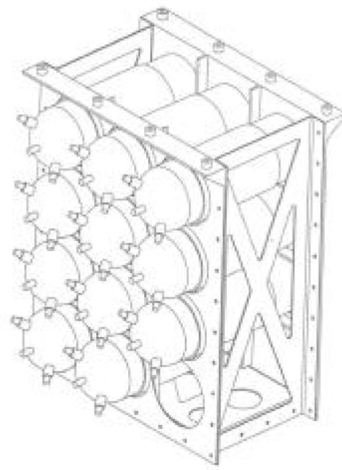

Figure 3-16: Hessi Battery

3.2.4.3 Grounding

See Section 3.1.4.7 for a description of the satellite grounding system.

3.2.5 Command and Telemetry System

The Spacecraft Command and Telemetry system consist of the Command and Data Handling Subsystem and the Telemetry Subsystem.

3.2.5.1 Spacecraft Command and Data Handling (C&DH) Subsystem

The spacecraft Command and Data Handling (C&DH) system provides the hardware and software necessary to:

- Receive, validate and distribute commands
- Collect, format and transmit telemetry data to the ground
- Maintain and distribute a spacecraft clock
- Store and execute time-tagged commands
  Provide onboard data storage

The C&DH subsystem is built around the VME-based integrated spacecraft electronics module (SEM) which contains the 1750A CPU, communications interface board (CIB), payload and attitude control interface (PACI), charge control board (CCB), power input/output (PIO), 2 Gbyte solid state memory, and 5 spare card slots. The CIB, PACI, CCB, and the PIO were developed by Spectrum in support of Lunar Prospector, Mars-98 Orbiter and Lander, and NMP DS-1. The Solid State Recorder (SSR) is supplied by SEAKR based on space-qualified hardware produced for NASA's SSTI program. The C&DH system contains a single board computer (SB486R) supplied by Space Electronics, Inc. Spectrum Astro, Inc supplies the Instrument Data Processing Unit (IDPU). Figure 3-17 shows the mounting locations of the SSR, SEM, and IDPU on the spacecraft.

3.2.5.2 Spacecraft Telemetry Subsystem

The Telemetry subsystem consists of a 5-Watt STDN S-band transponder, RF assembly, and two omni antennas and ensures full downlink capability regardless of spacecraft attitude. The downlink rate to the UC Berkeley ground facility is 3.5 Mbits/second with 2.6-dB link margin, using a ground antenna diameter of 5 meters. The data is Binary Phase Shift Keying (BPSK) coded using Consultative Committee for Space Data Systems (CCSDS) recommended r=1/2, k=7 concatenation with RS(233,255). This approach results in an average of 11.2 Gbits of data downlinked per day. The Telemtry equipment locations are shown in Figure 3-18 and a flow diagram is shown in Figure 3-19.

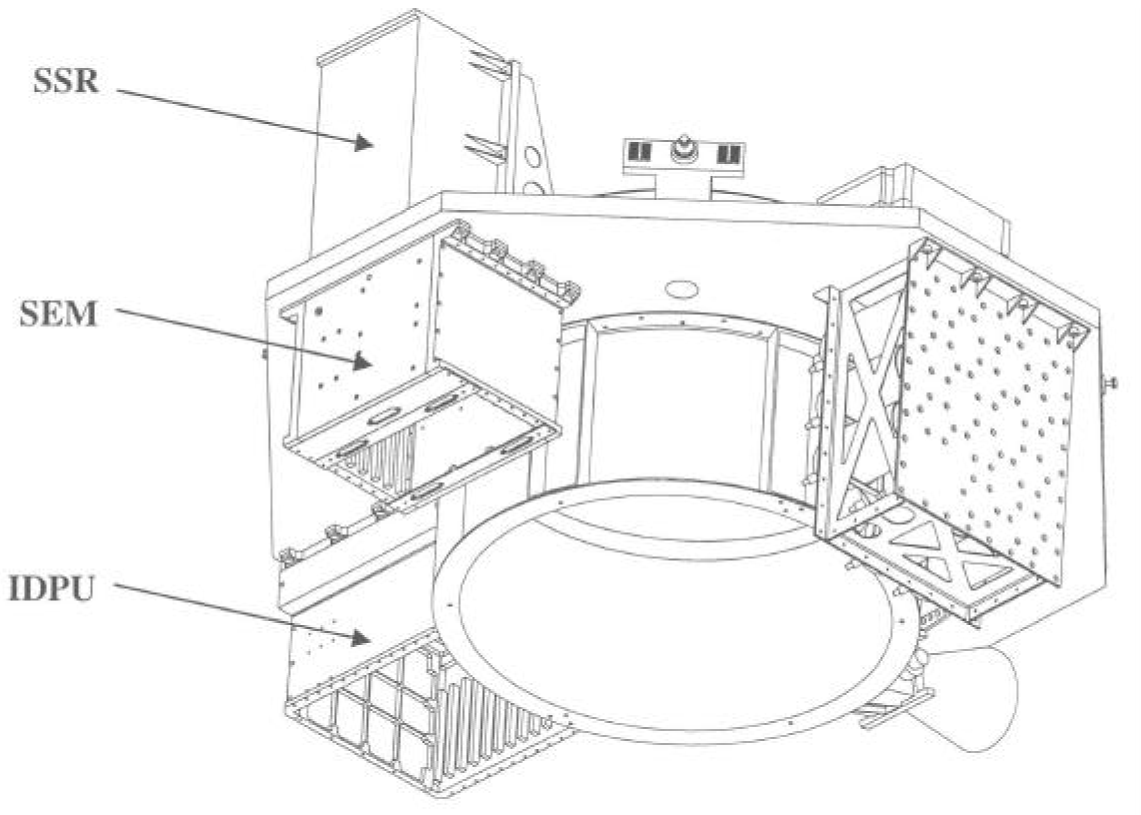

Figure 3-17: Command and data Handling Subsystem Location

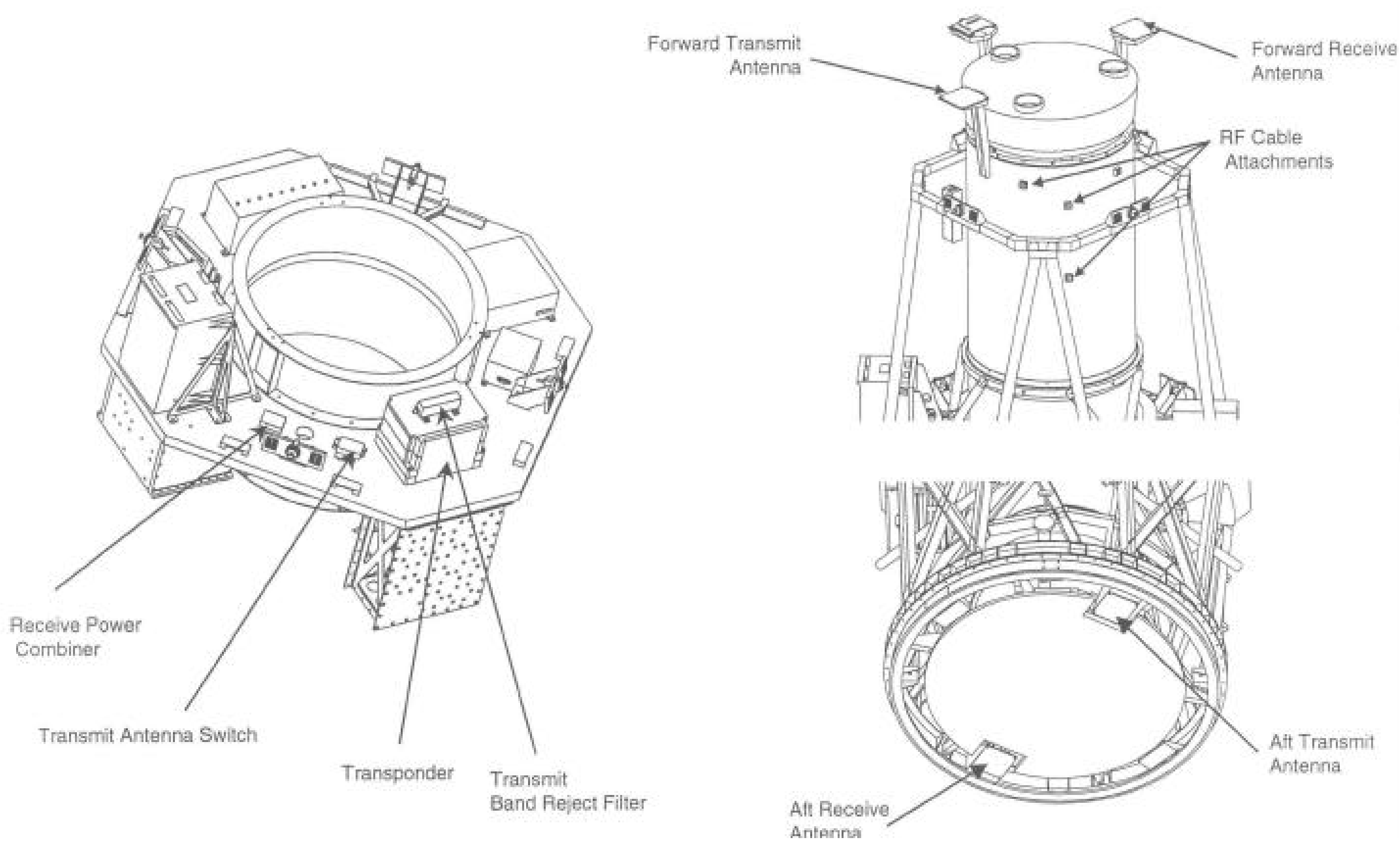

Figure 3-18: Telemetry Equipment Locations

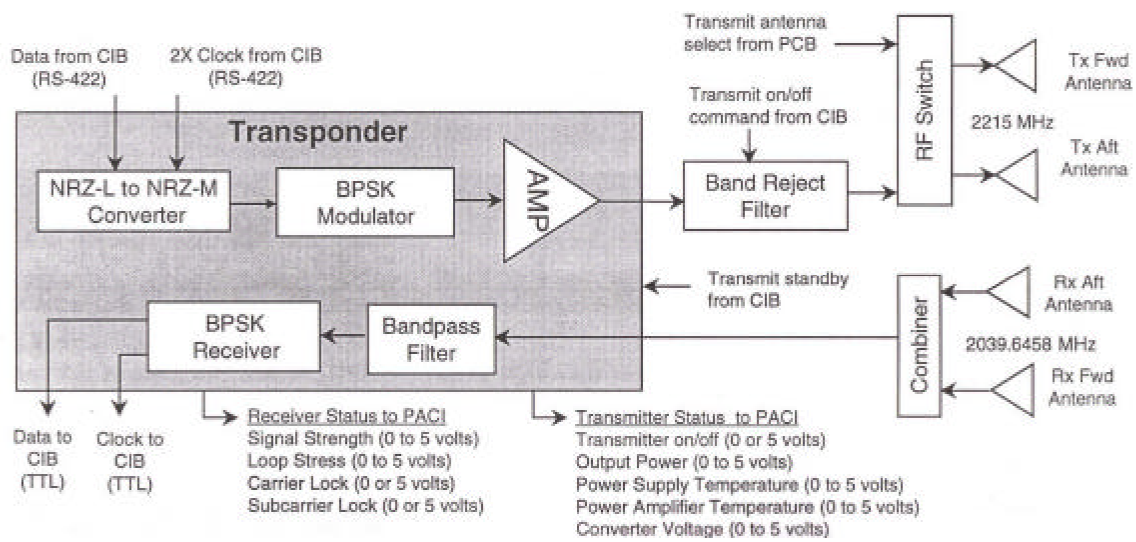

Figure 3-19: Telemetry Equipment Flow Diagram

3.2.6 Attitude Control System (ACS)

The Attitude Control System consists of four coarse Sun sensors, a fine Sun sensor, three torque rods, a magnetometer, two linear mass drivers, and a passive nutation damper. Table 3.2-3 provides a list of ACS components, while component locations are illustrated in Figure 3-20. The spacecraft will separate from the launch vehicle in 3-axis mode, deploy the four body-fixed solar array panels, acquire the Sun using four coarse Sun sensors with 4π steradian coverage, spin-up to 15 RPM and perform Sun acquisition to 0.2° using the fine Sun sensor. This Sun-pointing attitude will be maintained throughout the mission using Sun attitude data from the spacecraft fine Sun sensor and the instrument Solar Aspect System (SAS). Spacecraft attitude will be continuously changed to follow the Sun using internally redundant torque rods in combination with magnetic field data from the 3-axis magnetometer. The passive nutation damper is used to damp nutation, which can also be actively controlled using the torque rods. The linear mass drivers allow fine control of the spacecraft moments and cross products of inertia in the final deployed configuration ensuring stable, smooth, spin during the entire mission.

Both the instrument and the spacecraft have been designed to operate autonomously for weeks at a time. Following the initial attitude acquisition, even if the Attitude Control subsystem should fail "off", the spacecraft spin axis will remain fixed in inertial space.

Table 3.2-3: ACS Component list

Component	Qty	Supplier	Product #
TAM	2	Ithaco	IM-103
MTB	3	Ithaco	TR100CFR
MTB Electronics	2	Ithaco	TDE
RWA	4	Ithaco	B Wheel
IRU	2	Allied Signal	LCGA-20
CSS Assy.	2	Adcole	29110

3.2.7 Ordnance Subsystems

HESSI contains no pyrotechnic devices. Instead, the solar array release mechanism consists of a single shaped memory alloy (SMA) actuated release device, supplied byTiNi Alloy Company and is described in Section 3.2.2.3.

3.2.8 Non-Ionizing Radiation Subsystems

3.2.8.1 RF Communications System

The RF communications system consists of 5-Watt STDN S-band transponder coupled to two omni-directional low-gain antennas through a RF assembly. The transponder uplink frequency is TBD MHz and the downlink frequency is TBD MHz. The transmitter output power is 5 watts, +TBD, -TBD dB over the temperature range of -TBD to +TBD C. The receivers are on as soon as the spacecraft bus is powered. The transmitters require a command to be enabled, and will be activated from prelaunch through ascent. A block diagram of the RF communications system is shown in Figure 3-21. The system interfaces with the central electronics unit of the C&DH.

Figure 3-21: RF Communications Subsystem Block Diagram (TBS)

The 2 omni-antennas are located on TBD sides of the spacecraft bus and provide almost spherical coverage. The beamshape is primarily a single lobe symmetrical about the boresight. The minimum omni antenna gain is defined below relative to the boresight (out from the spacecraft):

- 0 to 45 degrees: +1.0 dBic
- 45 to 70 degrees: 2.8 - (0.04 x angle) dBic
- 70 degrees: 0.0 dBic
- 70 to 80 degrees: 21 - (0.3 x angle) dBic
- 80 degrees: -3.0 dBic

The power flux density will be TBD mW/cm^2 at a distance of about TBD cm from the antenna boresight. For added safety, HESSI is recommending a distance of TBD meters (TBD mW/cm^2) be used as the keep-out zone during periods of RF radiation.

An RF hat coupler and/or protective cover will be used to preclude free radiation at harmful levels. The hat coupler consists of an omni antenna mounted to a connector within an aluminum enclosure. The RF hat couplers will be removed on the pad prior to flight. Provisions have been incorporated into the Delta fairing for this purpose.

3.2.6.1 Laser System

TBD

3.2.9 Ionizing Radiation Subsystems

TBD

3.2.10 Acoustical Subsystems

Currently no equipment, procedures or operations associated with or related to the HESSI spacecraft have been identified to be hazardous.

3.2.11 Thermal Subsystems

Heaters used by the HESSI spacecraft are etched foil encapsulated in Kapton with dual elements and Aluminum backing. Tayco Engineering will supply the heaters. The thermostats used are supplied by Elmwood Sensors and utilize a single pole, single throw, bi-metallic element with a current limit of 2.0 Amp. The temperature sensors are supplied by Rosemount, Inc. and utilize a high accuracy platinum resistance temperature detector with a sensitivity range of -260^{o}C to 400^{o}C. Figures 3-22(a) – 3-22(c) show the described thermal control hardware. The battery assembly is thermally isolated from the Instrument Panel and contains one radiator, facing radially outboard, 4 dual series redundant thermostats, and 11 dual element heaters mounted on each individual cell. The spacecraft electronics module (SEM) contains 3 dedicated radiators, one single string thermostat bonded with EA9394 to the outboard panel, and a single dual element heater mounted on the inboard panel. The transponder utilizes a single thermostat bonded to the outboard panel and a single dual-element heater mounted on the inboard side. The Solid State Recorder Assembly contains three dedicated radiators, a single string thermostat bonded to the outboard side and a single dual element heater mounted on the inboard side. Figure 3-23 shows the subsystem radiators and mounting interfaces. Other items used in the thermal control system are Spectrum Astro supplied Multi-Layer Insulation (MLI), SCT tape supplied by Sheldahl, and RTV supplied by RS Hughes.

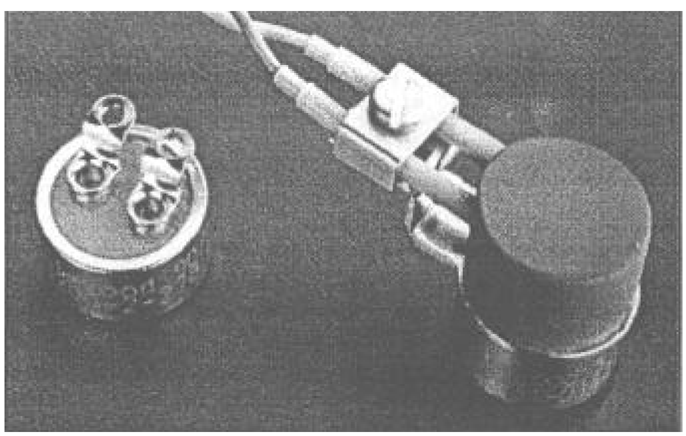

Figure 3-22(a): Thermal Control Hardware

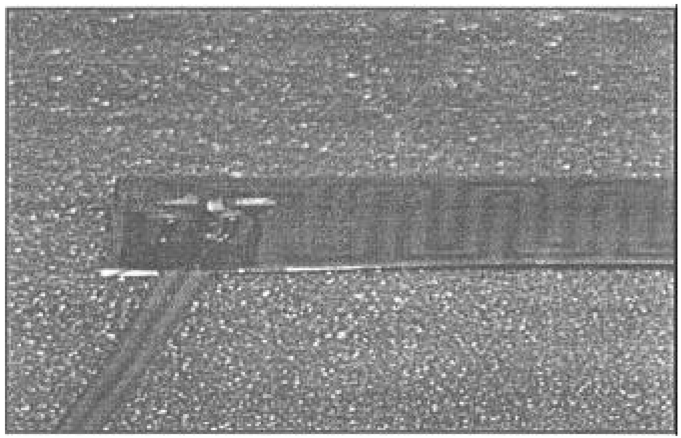

Figure 3-22(b): Thermal Control Hardware

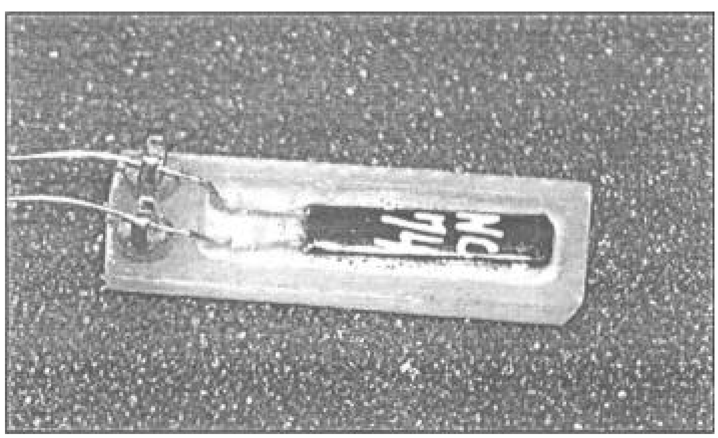

Figure 3-22(c): Thermal Control Hardware

3.2.12 Computing and Software Subsystems

The command and data handling subsystem is addressed in Section 3.2.5.1.

3.2.13 Hazardous Materials

See Section 6.4 for a detailed description of all hazardous materials associated with the HESSI Spacecraft.

4.0 SPACECRAFT GROUND SUPPORT EQUIPMENT (GSE)

The following Ground Support Equipment (GSE) is used at the Western Range for the HESSI Spacecraft in preparation for launch. Specific GSE capabilities are detailed in the following sections.

4.1 SPACECRAFT GSE

4.1.1 Material Handling Equipment

The spacecraft material handling equipment includes the spacecraft dolly, the shipping containers, the lifting fixture, the HESSI lift sling, the turnover fixture, the mating table, the integration stand, and a solar array wing assembly/alignment tool.

Material handling equipment has minimum factors of safety of 5.0 and lift hardware will be proof tested. Data on rated load, proof load, and safety factors are shown in Table 4-1.

Material handling equipment, with exception of the mating table for a short period, is never sited in vicinity of the launch vehicle and would pose no hazard during a seismic event.

4.1.1.1 Spacecraft Dolly

The Spacecraft Dolly is a commercially manufactured hand truck commonly used in factories and warehouses. The dolly is a wagon type platform truck with welded steel frames, smooth corners and wagon type steering with a T handle. It is fitted with a flush steel deck to which an integration stand is attached for mating with the payload transition ring. The tires are pneumatic for cushioned ride over uneven surfaces. The dolly is manipulated by hand and is used to position the spacecraft after off loading from the transport van. The dolly has a rated capacity of 2500 pounds, weighs 800 pounds, has 12 inch O.D. tires, and the platform measures 36 by 60 inches. Once in position the wheels of the dolly are chocked to prevent movement; there is no locking mechanism. The dolly is similar to the dolly used on the WIRE mission. The dolly is shown in Figure 4-1.

TBS
Figure 4-1
Spacecraft Dolly

4.1.1.2 Shipping Container

A shipping container is used when the HESSI spacecraft is transported from UCB to the WR. The shipping container is designed to fit on the spacecraft dolly. The shipping container is similar to those used on the WIRE mission.

Table 4-1 Material Handling Equipment Proof/Load Data

ITEM NAME	SLING		NDI REQ'D		RATED LOAD (LBS)	DESIGN FACTOR OF SAFETY*	PROOF LOAD (LBS)	ACTUAL LOAD (LBS)
	METAL	SYNTHETIC	YES	NO				
HESSI Lifting Sling (Vertical & Horizontal Configuration)	X		X†		1000	5.0	2000	1000
Lifting Fixture	X		X†		750	5.0	1500	600
Spacecraft Dolly				X	2500	5.0	N/A	800
Turnover Fixture				X	3000	3.0	6000	600
Mating Table	X			X	1000	5.0	5000	600
Hydraset				X	2000	4.0	1250	1000
Integration Stand	X				700	5.0	1400	700

†required for fabrication

**based on data from manufacturer

* without yielding

A separate shipping container is used for the solar array. The solar arrays are integrated onto the spacecraft after arrival to the WR.

4.1.1.3 Lifting Fixture (Bird Cage)

The HESSI spacecraft will be lifted onto the mating table by using a special lifting fixture called the bird cage. This is a multi-member fixture constructed of T6061-T6 aluminum that bolts around the spacecraft to allow lifting either in the plane of the thrust axis or normal to it. Designed for 5:1 factor of safety, the bird cage will be proof tested at two times the rated load. Information on the rated load, proof load; and design factors are specified in Table 4-1. The bird cage is shown from all orientations in Figure 4-2.

TBS
Figure 4-2
Bird Cage

4.1.1.4 HESSI Lifting Sling

The HESSI spacecraft is lifted using the HESSI lift sling. This is a four legged sling made of wire rope and an aluminum structure.

The lift sling was designed with a 5:1 factor of safety and will be proof tested at two times the rated load within a year before use at WR. The lifting sling is proof tagged and separable

components are independently tagged. Proof-testing will be accomplished in the vertical and both horizontal configurations. Data on rated load, proof load, and design factors are specified in Table 4-1. Orientations are shown in Figures 4-3, and 4-4.

TBS
Figure 4-3 & Figure 4-4
Lifting Sling Orientation

4.1.1.5 Turnover Fixture

The Turnover Fixture is a modified version of a commercial item manufactured by K.N. Aronson, Inc. The Model HD 30-6A Floor-Mounted Positioner can rotate its tilt table from horizontal through an arc of 135 degrees with loads up to 3,000 lbs. It has a 38,250 lb.-in. rotation gearing with a self-locking wormgear drive for its rotation pinion. The table has a factor of safety of greater than 3.0.

The turnover fixture, as configured for HESSI, includes lockable casters on the support legs for mobility on the floor and an adapter ring bolted to the tilt table for attaching the spacecraft. Figure 4-5 illustrates the positioner. The turnover fixture may be fitted with outriggers to enhance stability when the spacecraft is being rotated. The purpose of the

turnover fixture is to rotate the spacecraft from vertical to horizontal to facilitate mating to the launch vehicle.

TBS
Figure 4-5
Turnover Fixture

4.1.1.6 Mating Table

After rotating the HESSI spacecraft to a horizontal orientation in Building 1555, the mating table (or integration platform assembly), a wheeled multi-axis adjustable cradle, is used. It allows the positioning of the HESSI spacecraft in any desired axis. The table is also used to mate the HESSI Spacecraft to the launch vehicle. The mating table is proof-tagged.

Designed for a 5:1 factor of safety, the mating table will be proof tested before use at WR. Information on rated load, proof load, and design factors is specified in Table 4-1. The wheel's locking mechanisms will be engaged when the mating table is in a stationary position. The mating table is shown in Figure 4-6.

4.1.1.7 Integration Stand

The integration stand is a welded aluminum structure that holds HESSI. The stand allows for access to components mounted under the base plate. The integration stand was designed using a 5:1 safety margin and will be proof tested to two times the safe working load. The integration stand will be chocked during use to prevent movement. The Integration Stand is shown in Figure 4-7.

4.1.1.8 Solar Array Wing Assembly/Alignment Tool

The solar array wing assembly/alignment tool fixture frame structure is used to install the solar arrays. It insures proper alignment of restraint points. The tool is shown in Figure 4-8.

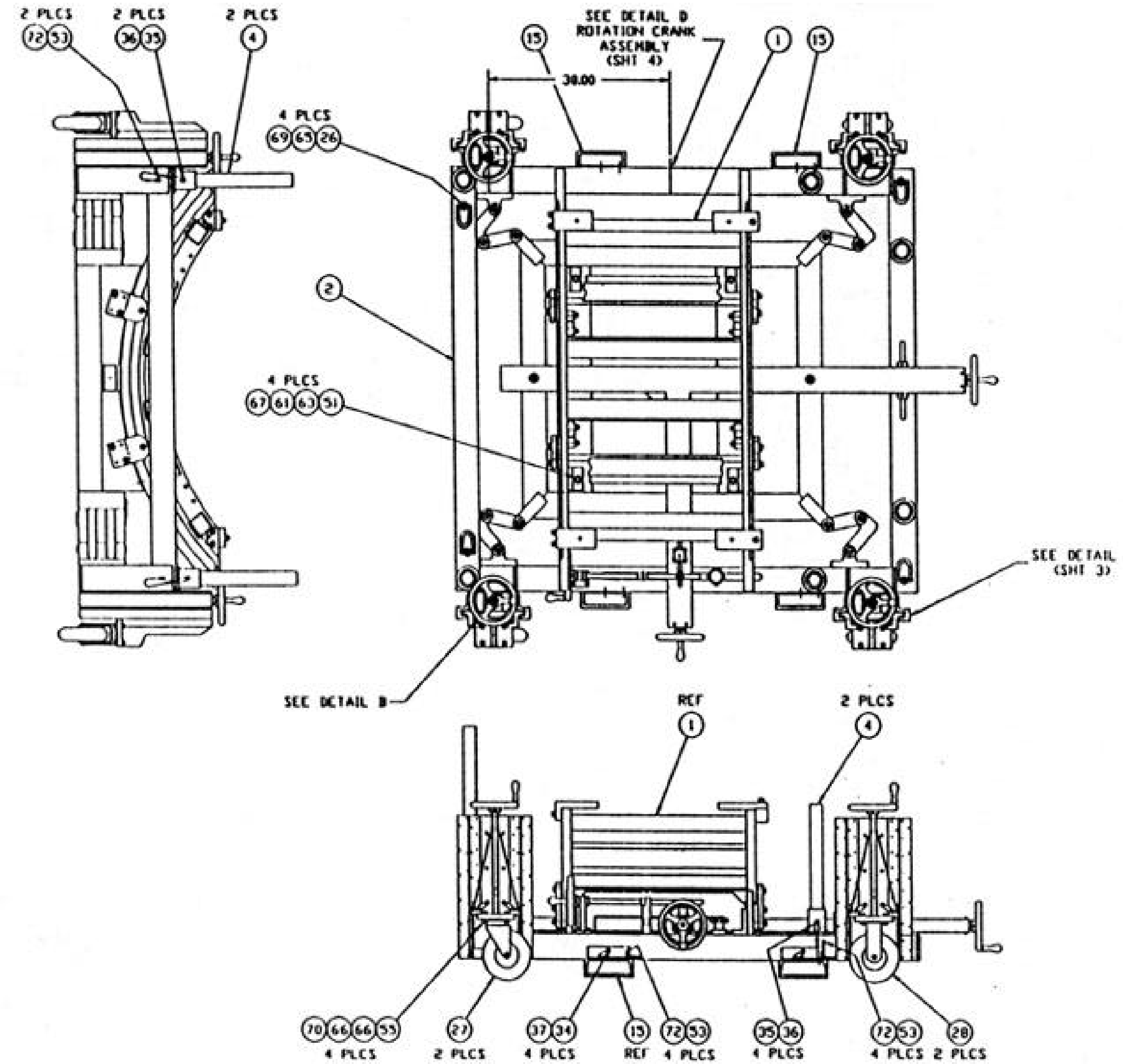

Figure 4-6
Mating Table

TBS
Figure 4-7
Integration Stand

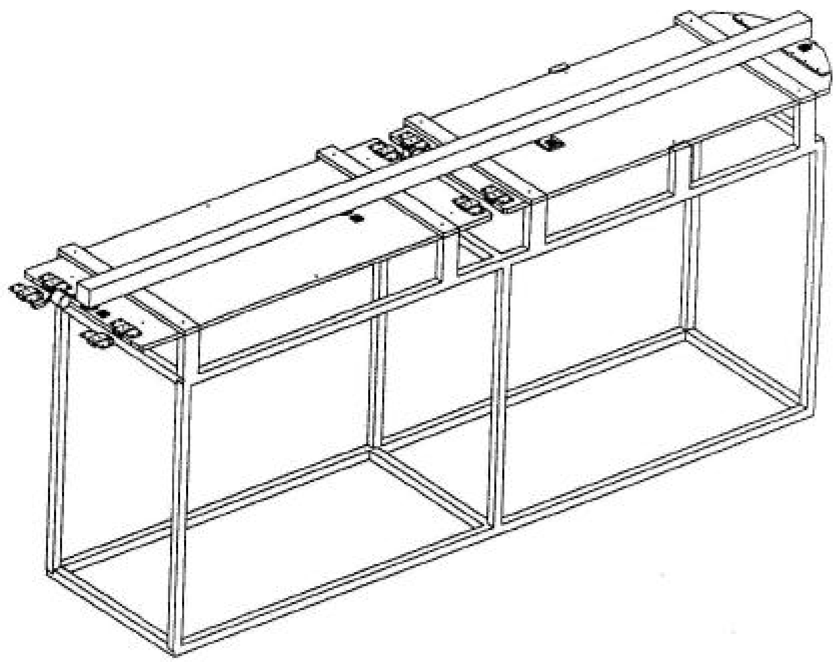

Figure 4-8
Solar Array Wing Assembly/Alignment Tool

4.1.2 PRESSURE AND PROPELLANT SYSTEMS

The pressurized purge systems for the spacecraft GSE is discussed in Section 4.13.2.

4.1.3 ELECTRICAL AND ELECTRONIC SUBSYSTEMS

The electrical ground support equipment (EGSE) provides for the support of the spacecraft during subsystem integration and test, and pre-launch vehicle integration activities. The following is a list of HESSI ESGE that will be used at VAFB and KSC. Figure 4-9 illustrates the EGSE.

1. Spacecraft Command And Telemetry
2. Radio Frequency Rack
3. Signal And Power
4. Hot Bench
5. Component Test Sets

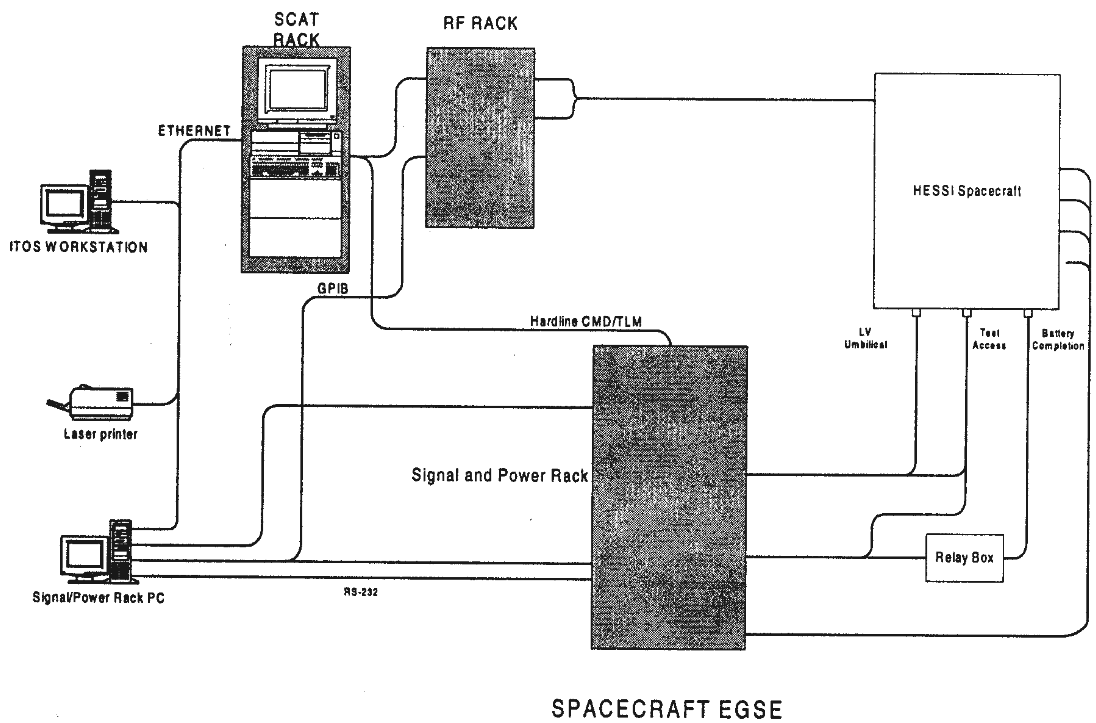

Figure 4-9
EGSE

The spacecraft command and telemetry (SCAT) generates and receives bit streams. The SCAT rack is pictured in Figure 4-10. The Radio Frequency (RF) rack modulates signal from SCAT and sends the output signal to the antenna hats as well as demodulates signal from antenna hats and sends the output signal to SCAT. The RF rack is shown in Figure 4-11. The signal and power rack provides interface with test access cable and launch vehicle umbilical simulation, battery conditioning, and power to the spacecraft through test access cable or solar array simulators. The signal and power rack is pictured in Figure 4-12.

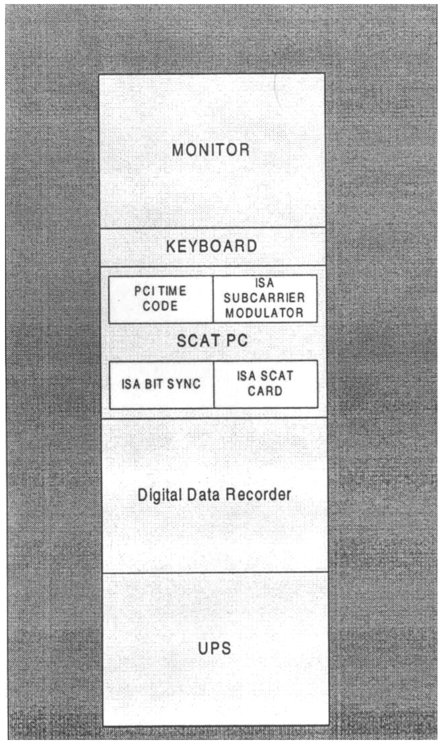

Figure 4-10 SCAT Rack

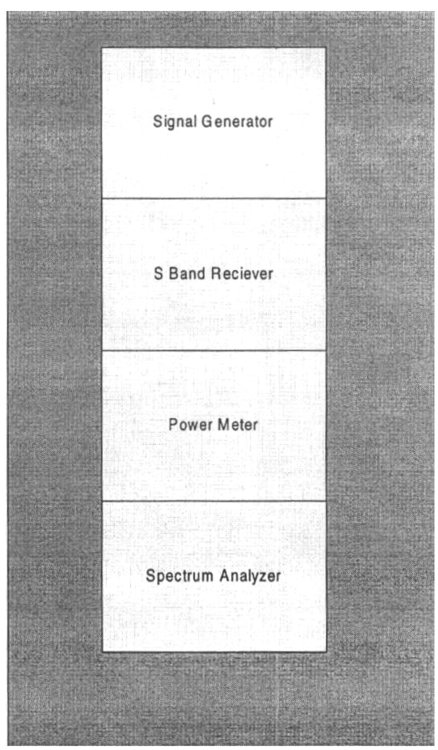

Figure 4-11 RF Rack

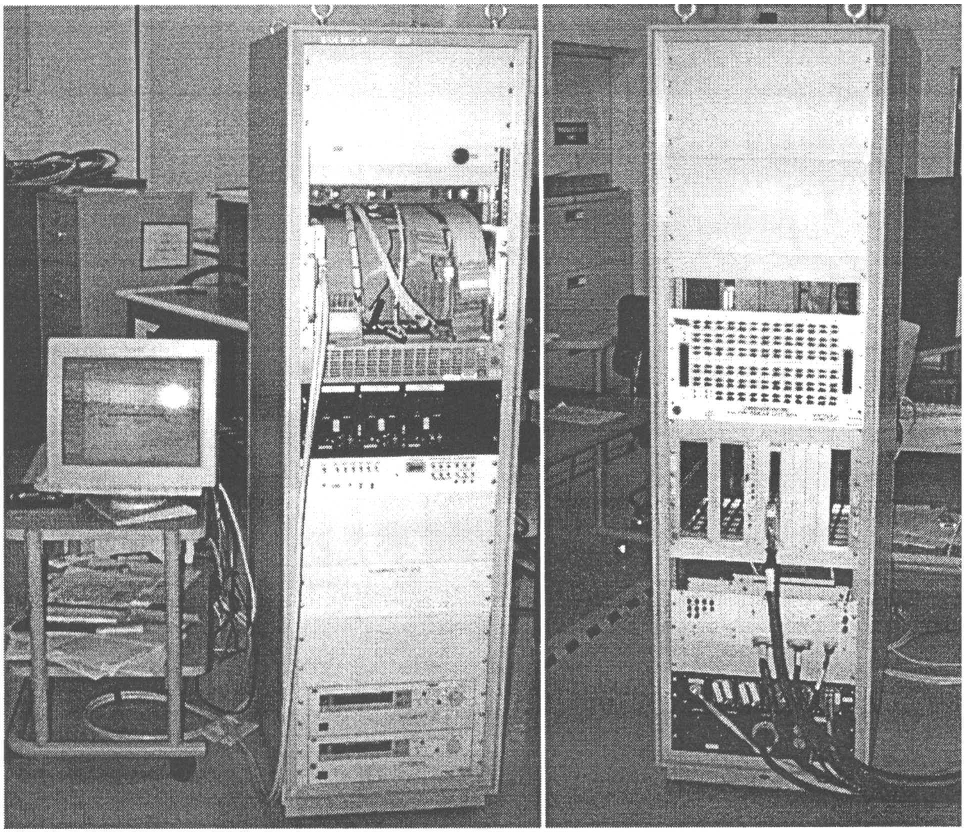

Figure 4-12
Signal and Power Rack

The hot bench is composed of the AC1000, a transition rack, an integrated data processing unit (IDPU), an integrated test operation system (ITOS), and SCAT. The Hot Bench equipment set up is shown in Figure 4-13. The AC1000 provides closed loop control simulation. The transition rack converts signals as required. IDPU simulator provides power and signal interface of the payload. The SCAT/ ITOS provides command and telemetry.

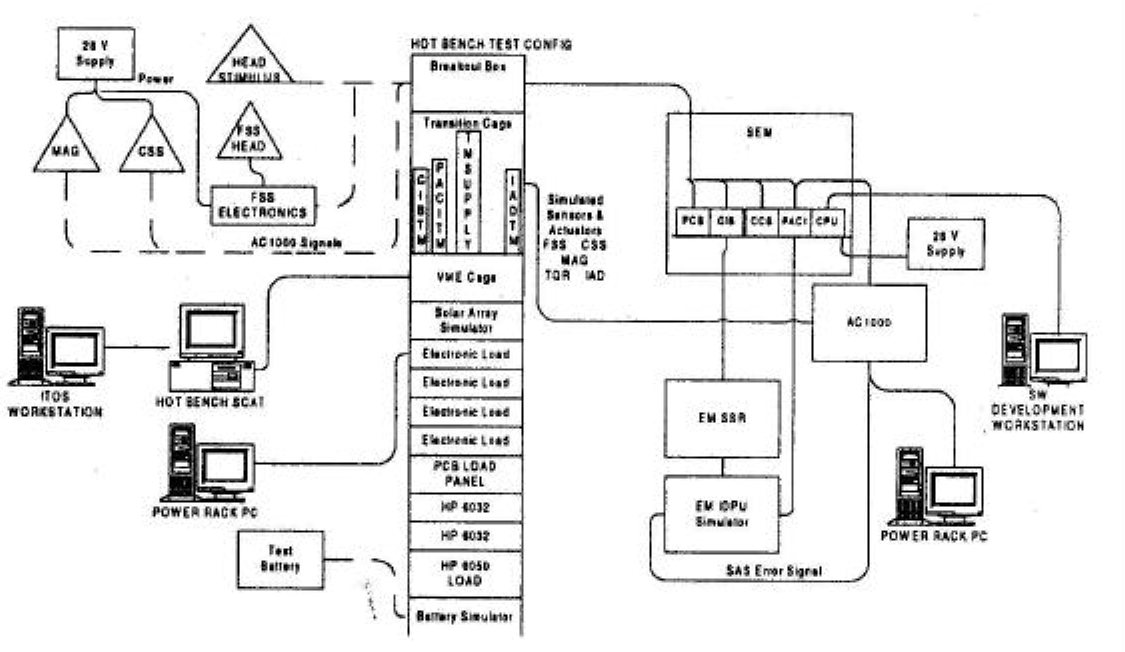

Figure 4-13
Hot Bench

The component test sets consist of a payload and attitude control interface (PACI), a communications interface board (CIB), a power control board (PCB), and a charge control board (CCB). The test sets are shown in Figures 4-14 through 4-17.

4.1.3.3 Power Generation GSE

TBD

4.1.3.2 Battery GSE

TBD

4.1.3.2.1 Battery Electrical Ground Support Equipment (EGSE)

TBD

4.1.3.2.2 Battery Trickle Charge System

TBD

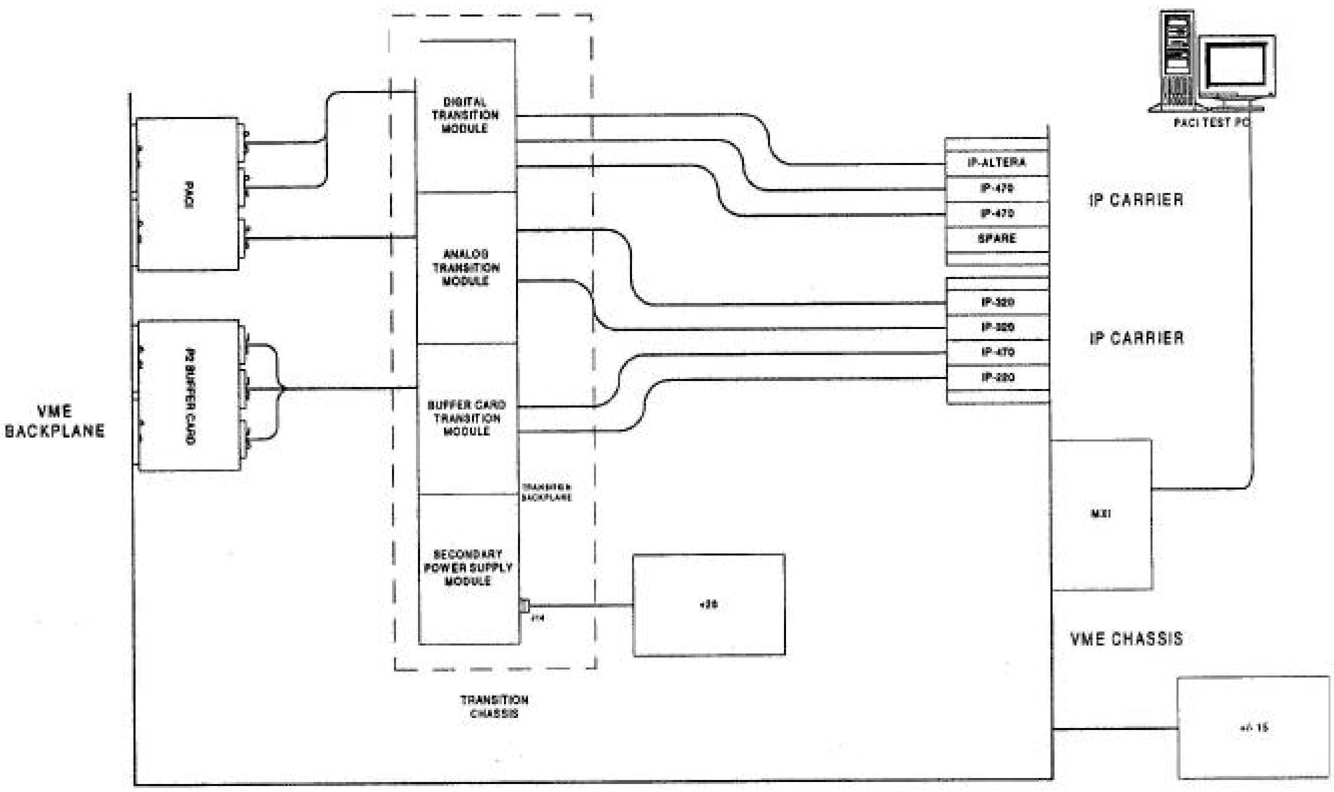

Figure 4-14 PACI

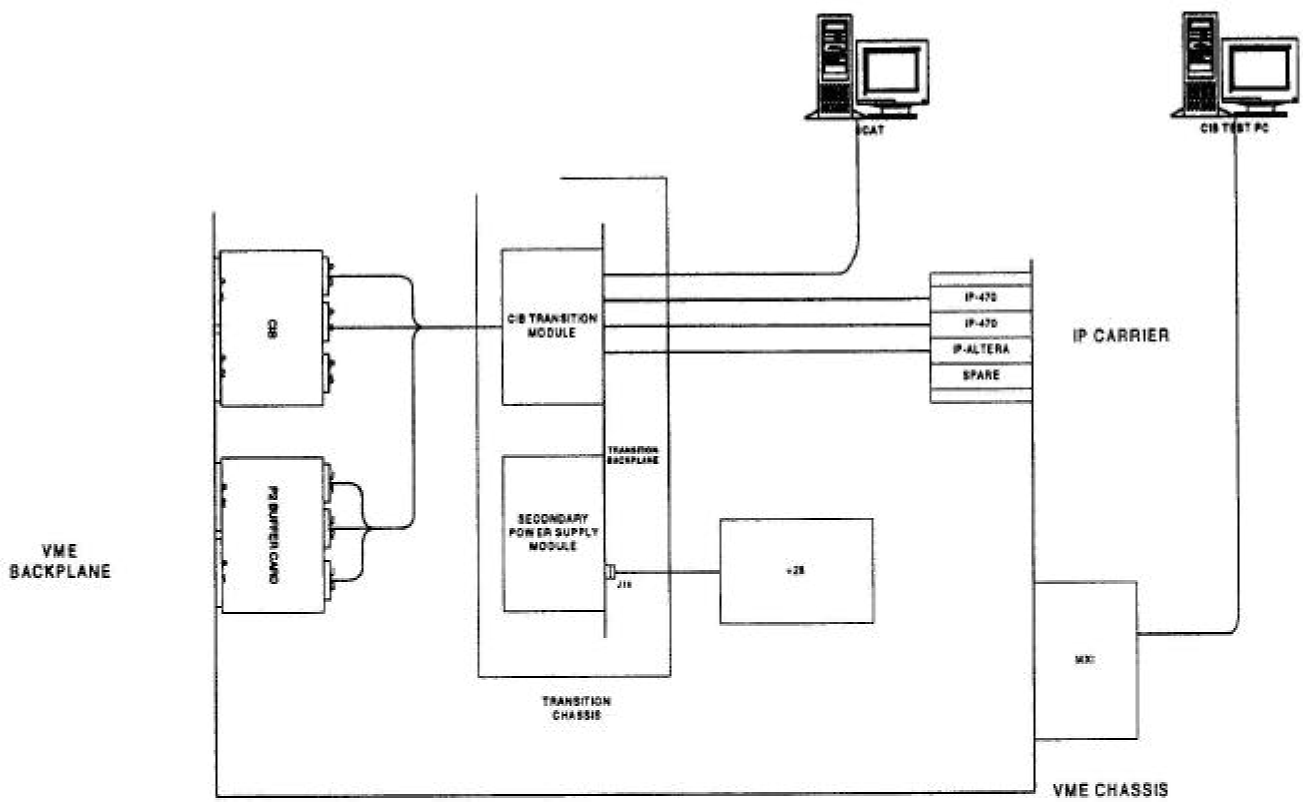

Figure 4-15 CIB

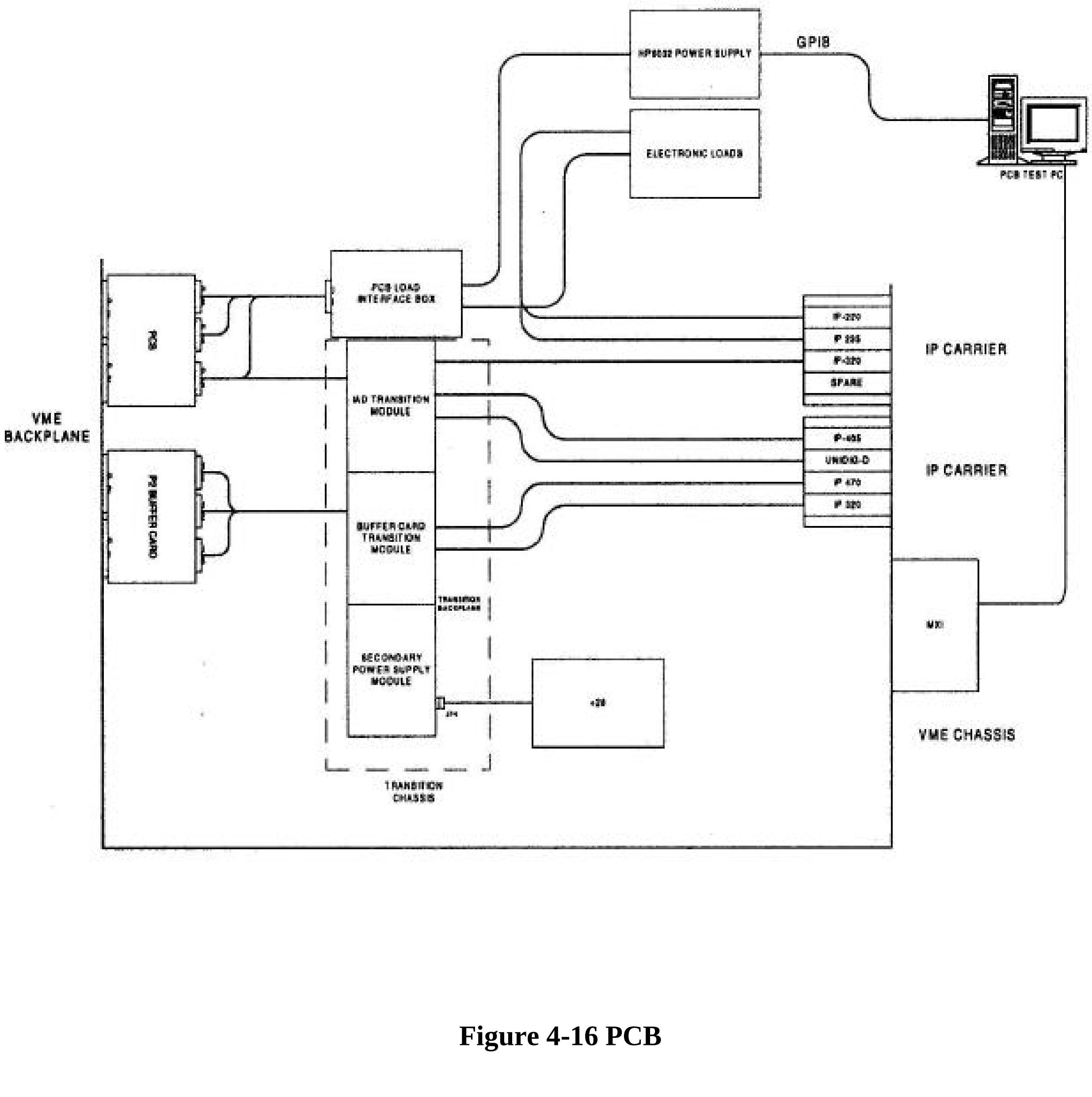

Figure 4-16 PCB

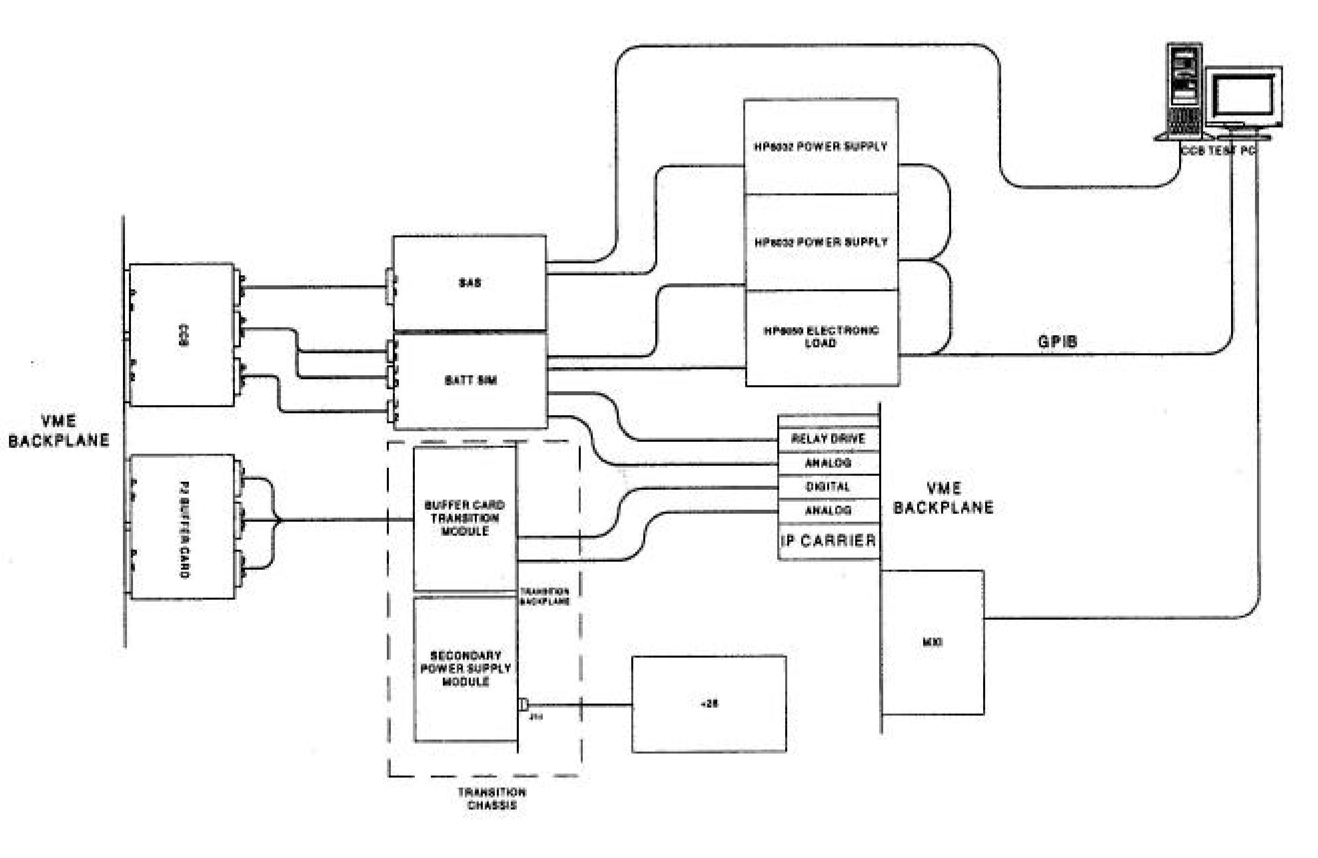

Figure 4-17 CCB

4.1.3.2.3 Battery Cooling Cart

TBD

4.1.3.3 Attitude Control System (ACS) GSE

TBD

4.1.4 ORDNANCE SUBSYSTEMS

Pyrotechnic firing capability does not exist on HESSI GSE.

4.1.5 NON-IONIZING RADIATION SOURCE DATA

Calibration laser source. Additional information TBS.

4.1.6 IONIZING RADIATION SOURCE DATA

There are no ionizing radiation hazards associated with the GSE.

4.1.7 ACOUSTIC HAZARDS

There are no high decibel noise sources identified with the GSE.

4.1.8 HAZARDOUS MATERIALS

See Section 6.6 for a detailed description of all hazardous materials associated with HESSI.

4.1.9 OPERATIONS SAFETY CONSOLE

Operations safety console is located in the L-1011. Safety data is presented in Orbital's Accident Risk Assessment Report.

4.1.10 VEHICLE DATA

Safety data is presented in Orbital's Accident Risk Assessment Report.

4.1.11 COMPUTING SYSTEMS DATA

Section 3.2.11 references all critical commands.

4.1.12 WR SEISMIC DATA REQUIREMENT

Due to their low center of gravity and their location away from the Pegasus launch vehicle, the ASE and GSE do not pose a personnel, equipment, or tip over hazard as a result of a seismic event.

4.2 INSTRUMENT GSE

The following GSE is used at the Western Range for the integrating the HESSI instrument into the spacecraft at GSFC.

4.2.1 Mechanical Handling Equipment

A lifting fixture is not required to move the instrument at the WR. A lifting fixture is used only to place the instrument into the spacecraft, which will take place at UCB.

4.2.2 Pressure GSE

TBD

4.2.2.1 HESSI Purge Cart

TBD

4.4.4.2.2 Vacuum Pump

TBS

4.2.3 Electrical GSE

TBD

5.0 AIRBORNE SUPPORT EQUIPMENT (ASE)

The HESSI spacecraft Airborne Support Equipment (ASE) provides power, commanding, and monitoring while the satellite is integrated with the Pegasus launch vehicle and the L-1011 Pegasus Carrier Aircraft (PCA). There are two ASE racks used at Eastern Range (ER), one serves as the power console during ground processing and the second is installed in the L-1011 for launch. The ASE interfaces to the HESSI spacecraft through two connectors: the standard umbilical and the auxiliary umbilical connectors. The following is a detailed list of ASE functions:

1. Spacecraft Power for testing.
2. Generation of discrete commands (8)
3. Appropriate modulation of NRZ-L command bit stream for spacecraft ingest (hard-line input).
4. Monitoring of selected spacecraft temperatures, voltages, and currents.
5. Generation of spacecraft relay command signals.
6. Hard copy output of selected monitoring points.
7. Receiver no-lock override of the transponder.
8. Battery charge capability and charge rate control.

In addition to the above functions the ASE performs three functions during ground integration and test activities:

1. Provides an interface between the SMEX (HESSI) I&T GSE and the spacecraft for downlink of baseband telemetry at 3.6 mega-symbols per second.
2. Provides a set of power shunts for use when use of the spacecraft shunts are not desired.
3. The ASE provides simulation of three payload separation loopback signals.

The ASE is fail-safe. Loss of ASE function during any mission phase will not result in a hazard.

5.1 HARDWARE DESCRIPTION

The ASE rack is shown in Figure 5-1. Launch operations will use the ASE to provide external power to the spacecraft. The power supply mimics the solar array characteristics. The power supply limits the steady state bus to exceed TBD volts. Single power generation GSE failures can not damage the spacecraft. The ASE is designed to requirements of Federal Aviation Administration (FAA) Regulations (CFR 14, Part 25) and for the L-1011 environment (power is 115 VAC, 400 Hz).

TBS
Figure 5-1 ASE Rack

The ASE Block Diagram is shown in Figure 5-2, and is described as following subsections:

TBS
Figure 5-2 ASE Block Diagram

5.1.1 The Power Console

TBD

5.1.2 The Stripchart Recorder

TBD

5.1.2.1 Solar Array Simulator (SAS)

TBD

5.1.2.2 PSK Subcarrier Modulator

TBD

5.1.2.3 Power Shunt Box

TBD

5.1.2.4 Mechanical Interface

The ASE is to be integrated into a TBS inch x TBS inch rack that will house the system hardware. The ASE is designed to remain integrated under a 9 g forward and a 5.2 g vertical load. The ASE rack procured by the project was recommended by OSC as meeting OSC requirements. The rack's mounted components are analyzed to withstand maximum loading without loss of structural integrity. The rack and its components will be inspected by the FAA.

5.1.2.5 Electrical Functions

TBD

5.1.2.6 Commanding

TBD

6.0 GROUND OPERATIONS

Figure 6-1 is the schedule of processing activities while at VAFB and KSC.

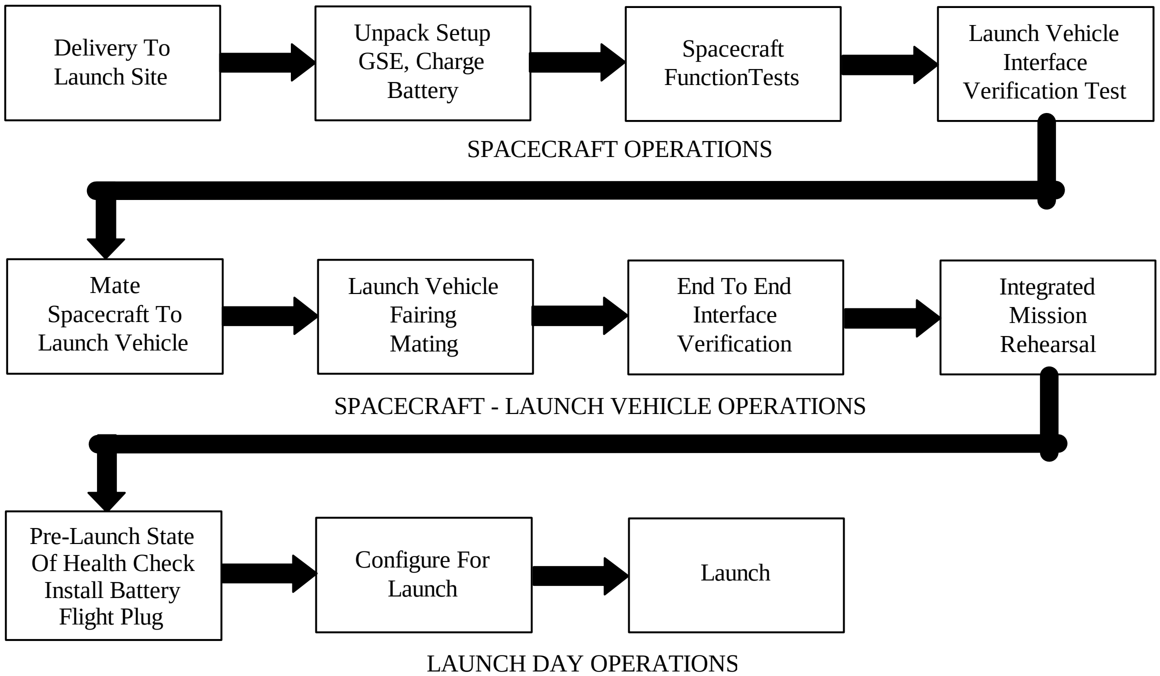

Figure 6-1 Ground Processing Activities

6.1 PRE-LAUNCH OPERATIONS

6.1.1 Building 836

Approximately four weeks prior to launch at KSC, the integrated HESSI instrument and the spacecraft bus will be transported from UCB to VAFB Building 836. On arrival at Building 836, the spacecraft and solar array will be unloaded, cleaned, and moved into the cleanroom facility. The GSE will be unloaded and a complete operational checkout will take place to ensure that the no damage occurred during shipment.

6.1.2 Building 1555

After operations conclude in Building 836, HESSI will be transported to Orbital's Building 1555. Operations in Building 1555 may include battery charging, short form functional testing, RF system checks, mating to the Pegasus third stage, and fairing closure.

6.2 HOT PAD OPERATIONS

Following system close-out, At the Hot Pad, HESSI and Pegasus will undergo integration with the Pegasus carrier aircraft, a Lockheed L-1011. The integrated payload and Pegasus will be then transported via ferry flight to the to the "Hot Pad" at KSC.

6.3 CAPTIVE CARRY OPERATIONS

Following final checkout procedures, the carrier aircraft will take off and fly to the launch point. Final in-flight Pegasus verifications and Pegasus vehicle arming will be initiated and final countdown will begin.

6.4 FLIGHT OPERATIONS

The launch and ascent phase begins with launch of the Pegasus vehicle and continues through third stage burnout, a period of about nine minutes. The events and the order in which they take place during this phase are as follows:

a. Drop
b. First Stage Ignition
c. First Stage Burnout
d. Second Stage Ignition
e. Payload Fairing Separation
f. Second Stage Separation
g. Coast Period
h. Third Stage Ignition
i. Third Stage Burnout and Orbital Insertion

6.5 PROCEDURES

Table 6-1 provides a list of all procedures HESSI plans to use at VAFB and KSC. Hazardous procedures are shown in **BOLD**. Integrated procedures that HESSI supplies inputs to Orbital are marked with an asterisk (*).

Table 6-1: HESSI Procedures at VAFB and KSC
TBS

6.6 HAZARDOUS MATERIALS

Hazardous materials include a solar array repair kit, nitrogen, and processing materials. Hazardous materials are listed in Table 6-2 and the material safety data sheets (MSDS) for these chemicals can be found in Appendix A.

Table 6-2 Hazardous Chemicals

Chemical Name	Quantity	Use	Hazard

TBS

6.6.1 GN_2 Purge

TBD

6.6.2 Solar Array Repair Kit

TBS

6.6.3 Processing Materials

Cleaning materials and other processing materials will be used in Building 836 in a well-ventilated area. Application of some of the processing materials is for contingency use only. This would include the solar array repair kit chemicals and TBD.

7.0 SPACECRAFT SAFETY ASSESSMENT

7.1 RESPONSIBILITY AND SCOPE

It is the responsibility of the HESSI project organization to provide for the safety of their systems and verify compliance with applicable requirements. This assessment identifies hazards associated with the HESSI mission and makes recommendations for elimination or control of the hazards to assure system safety requirements are met.

7.2 SYSTEM SAFETY PROGRAM

The HESSI payload organization has established and is maintaining a system safety program to support efficient and effective achievement of overall NASA system safety objectives in accordance with EWR 127-1.

7.3 System Safety Process

The system safety process consists of a series of analytical steps defined as follows:

- DEFINE THE SYSTEM by describing the physical and functional characteristics of the system employing the information available, and relate the interaction between people, procedures, equipment, and the environment.

- IDENTIFY HAZARDS related to all aspects of the operation (including both nominal and emergency operations) and determine their causes.

- ASSESS HAZARDS to determine their consequence severity and probability of occurrence, and to recommend means for their elimination or control.

- RESOLVE HAZARDS by implementing corrective measures to eliminate or control the hazards or assuming the risk.

- FOLLOW-UP analyses to determine the effectiveness of preventive measures and address new or unexpected hazards; issue additional recommendations if necessary.

7.3.1 HESSI System Description

Sections 3.0 through 6.0 of this report define the physical and functional characteristics of the HESSI system including flight equipment, ground support equipment, operations and procedures.

7.3.2 Hazard Identification

An Experts Panel Meetings were held on 9 December 1998 and 6 January 1999 to identify hazards associated with the HESSI System. The Preliminary Hazard Analysis provided as Appendix B was developed to document the hazards identified by the Experts Panel, and to document other hazards identified as a result of reviewing NASA and Range requirements.

7.3.3 Hazard Assessment

Hazards were assessed to determine the Severity and Probability based on the requirements of NHB 1700.1, NASA Safety Policy and Requirements Document.

7.3.3.1 Hazard Severity Categories

NHB 1700.1 (V1-b), dated June 1993, defines four hazard severity categories; Category I, Catastrophic, Category II, Critical; Category III, Marginal; and Category IV, Negligible. Hazard severity categories are defined to provide a qualitative measure of the worst credible mishap resulting from personnel error; environmental conditions; design inadequacies; procedural deficiencies; or system, subsystem or component failure or malfunction. Table 7-1depicts these categories and provides a general description of the characteristics that define the worst-case potential injury or system damage if the identified hazard were to result in an accident.

Table 7-1: Hazard Severity Categories

CATEGORY	HAZARD CATEGORY	POTENTIAL CONSEQUENCES
I	CATASTROPHIC	Death, system loss, or severe environmental damage
II	CRITICAL	Severe injury, severe occupational illness, major system or environmental damage
III	MARGINAL	Minor injury, minor occupational illness, or minor system or environmental damage
IV	NEGLIGIBLE	Less than minor injury, occupational illness, or less than minor system or environmental damage.

NHB 1700.1 (V1-B)

7.3.3.2 Hazard Probability Categories

NHB 1700.1 (V1B) includes guidelines showing how to determine a qualitative ranking of hazard probability. Failure rate data, if available, may be used to help make a decision regarding probability ranking; however, these data are most often not available. The probability rankings for HESSI have been assigned primarily based on similar systems and equipment, and historical safety data. Table 7-2 shows the hazard probability classes typically used and describes the characteristics of each level.

Table 7-2: Hazard Probability Levels

LEVEL	FREQUENCY OF OCCURRENCE	DEFINITION
A	Frequent	Likely to occur frequently.
B	Probable	Will occur several times in the life of an item.
C	Occasional	Likely to occur some time in the life of an item.
D	Remote	Unlikely, but possible to occur in the life of an item.
E	Improbable	So unlikely, it can be assumed occurrence may not be experienced.

NHB 1700.1 (V1-B)

7.3.3.3 Hazard Risk Index

The Hazard risk Index (HRI) is a number derived by considering both the severity and the probability of a hazard, as shown in Table 7-3. The HRI presents hazard analysis data in a format that helps the managing activity make decisions regarding whether hazards should be eliminated, controlled, or accepted. The HRI provides the basis for logical management decision making by considering both the severity and probability of a hazard. It should be noted that, for valid risk assessment, the potential severity of a hazard may not be decreased unless physical changes are made to completely eliminate the hazards. The probability can be greatly reduced by design modifications, or by incorporating safety devices, warning devices, or special procedures thereby reducing the HRI.

Table 7-3: Hazard Assessment Matrix

Frequency of Occurrence	**Hazard Categories**			
	I Catastrophic	**II Critical**	**III Marginal**	**IV Negligible**
(A) Frequent	1A	2A	3A	4A
(B) Probable	1B	2B	3B	4B
(C) Occasional	1C	2C	3C	4C
(D) Remote	1D	2D	3D	4D
(E) Improbable	1E	2E	3E	4E

NHB 1700.1 (V1-B)

Hazard Risk Index		HRI	Suggested Criteria
1A,1B, 1C, 2A, 2B, 3A		1	Unacceptable
1D,2C, 2D, 3B, 3C		2	Undesirable (Management Decision Required)
1E, 2E, 3D, 3E, 4A, 4B		3	Acceptable with review by Management
4C, 4D, 4E		4	Acceptable without review

7.3.3.4 Hazard Reduction Precedence

Risk management is a decision-making process consisting of evaluation and control of the severity and probability of a potential hazardous event. Assigning an HRI provides a method to prioritize hazards for corrective action, allowing a determination to be made as to whether hazards should be eliminated, controlled, or accepted. The process helps to determine the extent and nature of preventive controls that can be applied to decrease the risk to an acceptable level within the constraints of time, cost, and system effectiveness. Resolution strategies in descending order of precedence are listed below.

- Design for Minimum Risk. This strategy generally applies to acquisition of new hardware and equipment where the design can be made inherently safe; however, it can also be applied to hardware and equipment modifications. If a hazard cannot be eliminated completely, they should be controlled through design (e.g., fail safe designs).
- Incorporate Safety Devices. If identified hazards cannot be eliminated or their associated risk adequately reduced through design selection, the risk can be reduced using fixed, automatic, or other protective safety design features or devices (e.g., a pressure relief valve). Provisions should be made for the periodic inspection and functional check of safety devices when applicable.
- Provide Warning Devices. When neither design nor safety devices can effectively eliminate identified hazards, or adequately reduce associated risk, devices can be used to detect the condition and to produce an adequate warning signal to alert personnel of the hazard. Warning signal and their application should be designed for the timely detection of conditions that precede the actual occurrence of the hazard. They should also be designed to minimize the probability of incorrect personnel reaction to the signals, or to false alarms that could lead to a secondary hazard. The alarms should be standardized within like types of systems.
- Hazard Acceptance or System Dispersal. Where hazards cannot be reduced by any means, a decision process must be established to document the rationale for either accepting the hazard or for disposing of the system.

7.4 PRELIMINARY HAZARD ANALYSIS (PHA)

7.4.1 Purpose

The HESSI Preliminary Hazard Analysis (PHA) provided as Appendix B has been prepared to identify, evaluate, and make recommendations for elimination and control of hazards, to track identified hazards, and to assist in eliminating or controlling hazards which could potentially cause:

- Loss of life and/or serious injury to personnel
- Serious damage to facilities and/or equipment resulting in large dollar loss
- Failures with serious adverse impact on mission capability, mission operability, or public opinion.

7.4.2 Scope

The HESSI Preliminary Hazard Analysis presented in Appendix B addresses satellite design, integration, test and operation of the HESSI Satellite during all phases of the HESSI life cycle up to launch at Cape Canaveral.

7.4.3 PHA Data Sheet Description

The following is an explanation of the various entries in the data sheet. See Table 7-4 for a blank PHA Data Sheet.

- Heading. The heading on each PHA data sheet identifies the particular analysis. The "Project" for all data sheets will be "HESSI". The "Date" indicates the most recent version of each data sheet. The "Hazard Category" will indicate the hazard category covered by the data sheet.

- Control Number. The first column of the data sheet provides the "Control Number" for that particular hazard. The control number is related to the Hazard Category provided in the heading.

- Hazard Description. The second column, "Hazard Description", identifies the energy source that generates the hazard. This entry may also indicate the immediate cause for concern, such as a fire/explosion.

- Causes. The third column, "Causes", describes those items that create or significantly contribute to the existence of the hazard. This entry will usually include the major causes of the hazard, including items or conditions that increase the severity of the hazard.

PRELIMINARY HAZARD ANALYSIS

Project: | **Date:**
Hazard Category: | **Page:**
Prepared by:

CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS

Table 7-4: Preliminary Hazard Analysis Data Sheet

- Effects. The fourth column, “Effects”, describes the potential detrimental effects of the hazard, and analyzes the flow of energy between the source and the object that is to be protected. The data provided in this entry are used in assigning a severity to the hazard.

- S-P 1. The fifth column contains the Severity and Probability, “S-P 1”, assigned to the hazard based on Table 7-1 and 7-2.

- HRI-1. The sixth column translates the “S-P 1” into a Hazard Risk Index (HRI) of 1, 2, 3, or 4 as explained in Table 7-3. This first Hazard Risk Index (HRI-1) is assigned based on the assumption that no action has been taken to protect against the hazard. The HRI is used to assist management in deciding the best course of action for resolving the hazard.

- Recommendations. The seventh column, “Recommendations”, provides recommendations, including design revisions or safety measures, to eliminate or control the hazard.

- S-P 2 and HRI-2. The eighth and ninth columns reflect the revised or residual Severity and Probability, “S-P 2”, and Hazard Risk Index, “HRI-2”, after the recommendation has been addressed and action has been taken to eliminate or control the hazard. It should be noted that, for the S-P 2, the potential severity of the hazard cannot be decreased by design modifications or addition of safety measures. However, the probability of hazard occurrence can be greatly reduced, and thus, the Hazard Risk Index can be decreased.

- References. The tenth column, “References”, cites the applicable required documents, guidelines and good history practices upon which the recommendation was made.

- Status. The eleventh column, “Status”, lists whether the hazard is “OPEN” or “CLOSED”, and to which phase of the acquisition process the hazard applies. The phases used are: “Design”, “Assembly”, and “Integration and Test”. The eleventh column also includes an explanation of how and/or why the hazard is open or closed. The column also lists appropriate references and correspondence if applicable. In order for a hazard to be closed, written documentation or verification is needed.

7.4.4 PHA Data Sheets

See Appendix B for the Preliminary Hazard Analysis Data Sheets.

7.5 SAFETY ASSESSMENT SUMMARY

The safety assessment data in this document are provided for review and are considered to be consistent with Safety Assessment Report (SAR) requirements of EWR 127-1. This summary provided the following items : Safety Requirement Compliance Summary, and Equipment and Facility Safety Assessment.

7.5.1 Safety Requirement Compliance Summary

Compliance with all applicable/imposed requirements of EWR 127-1 is demonstrated. Appropriate deviations or waivers will be submitted for review and approval for any aspect of the HESSI system or operations subsequently found not compliant with EWR 127-1.

If conflicting requirements or deficiencies are identified within system safety requirements or with other program requirements, the HESSI payload organization will submit notification, with proposed solutions or alternatives and supporting rationale, for resolution.

7.5.2 Equipment and Facility Assessment

The following addresses the major safety issues and concerns for HESSI.

7.5.2.1 Ground Support Equipment and Facilities

A description of the ground support equipment and facilities to be used is provided in Section 4 of this document. All equipment and the required facility support/interfaces associated with HESSI are in compliance with appropriate EWR 127-1 requirements and criteria.

7.5.2.2 Handling Equipment

Handling equipment associated with HESSI is described in Section 4 of this document. The ultimate factor-of-safety for design is well in excess of 5 times rated load. Information concerning design, analysis, proof load, and inspection is being provided and compiled as it is made available. Hardware and special lifting fixtures used to handle critical equipment will be re-tested to 200% of their rated load annually or within 12 months prior to use. Note that lifting equipment used to handle critical loads receive annual capability verification, while those not used to handle critical loads are tested every four years. All lifts are considered hazardous and will be conducted in accordance with approved procedures.

7.5.2.3 Noise Protection

Currently no equipment, procedures, or operations associated with or related to HESSI have been identified as acoustical hazards.

7.5.2.4 Non-Ionizing Radiation

TBS

7.5.2.5 Ionizing Radiation

TBS

7.5.2.6 Hazardous Materials

A description of the hazardous materials associated with the HESSI satellite is listed in Section 6.6.

7.5.2.7 Propellants and Systems

The HESSI satellite has no propellant or propulsion systems.

7.5.2.8 Pressurized Systems

7.5.2.8.2 Nitrogen Purge System

TBD

7.5.2.9 Ordnance Systems

The spacecraft does not use any explosive ordnance.

7.5.2.10 Electrical and Electronic Systems

TBD

7.5.2.11 Computing Systems and Software

TBD

7.6 HAZARDS RESOLUTION & TRACKING

The HESSI payload organization is eliminating hazards identified in the PHA or reducing the associated risk to a level defined by or acceptable to the Eastern and Western Range. Resolution of catastrophic and critical hazards will not rely solely on warnings, cautions or procedures/training for control of risk. The status of the hazards documented in the HESSI Preliminary Hazard Analysis (PHA) will be reviewed, updated, and approved during the phased safety review process established in EWR 127-1.

HESSI hazards identified in the PHA report are applicable to five categories : Design Hazards; Development; Test and Evaluation; Production; Integration; and; operations at VAFB and KSC.

Hazards will remain open until eliminated, controlled or accepted.

Open hazards are summarized in Table 7-5, Open HESSI Hazards.

Table 7-5: OPEN HESSI HAZARDS

Project: HESSI
Prepared By: HEI

Date: 2-25-99

Control No.	Hazard Description	S-P 1	HRI 1

TBD

Appendix A:

Material Safety Data Sheets

TBS

Appendix B:

Preliminary Hazard Analysis
Data Sheets

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Collision
Prepared by: Hernandez Engineering, Inc.

Date: 04/14/99
Page: B-3

CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
1.1	Failure of honeycomb structure (boxes and solar arrays)	Defects in design, materials and/or assembly	Damage to hardware, or severe personnel injury,	1D	2	Recommend stress analysis to verify positive margins of safety. Identify and protect any fracture sensitive items that are not contained, and where they may be of sufficient size to cause damage or injury.	1E	3	EWR 127-1, Section 3A.2.4.1	Open.
1.2	Failure of flexure mounts (solar arrays, grids, imager, and grid tray)	Defects in design, materials and/or assembly	Damage to hardware, or severe personnel injury	1D	2	Recommend stress analysis to verify positive margins of safety. Identify and protect any fracture sensitive items that are not contained, and where they may be of sufficient size to cause damage or injury.	1E	3	EWR 127-1, Section 3A.2.4.1	Open.
1.3	Fracture of instrument, Beryllium windows, or solar arrays	Defects in design, materials and/or assembly; Improper handling	Damage to hardware, or severe personnel injury	1D	2	Recommend stress analysis to verify positive margins of safety. Identify and protect any fracture sensitive items that are not contained, and where they may be of sufficient size to cause damage or injury.	1E	3	EWR 127-1, Section 3A.2.4.1	Open.
1.4	Failure of any satellite fasteners	Defects in design, materials and/or assembly; Improper handling	Damage to hardware, or severe personnel injury	1D	2	All fasteners will be screened per GSFC Fastener Integrity Requirements Document S-313-100.	1E	3	EWR 127-1, Section 3A.2.4.2; GSFC Fastener Integrity Requirements Document S-313-100	Open.
1.5	Failure of imager bonds	Defects in design, materials and/or assembly	Damage to hardware, or severe personnel injury,	1D	2	Recommend stress analysis to verify positive margins of safety.	1E	3	EWR 127-1, Section 3A.2.4.1	Open.

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Collision
Prepared by: Hernandez Engineering, Inc.

Date: 04/14/99
Page: B-4

CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
1.6	Inadvertent release/ deployment of solar arrays	Defects in design, materials and/or assembly; Electrical/ electronic failure; Inadequate or failure to follow procedures	Damage to hardware, severe personnel injury, or possible death	1D	2	Ensure solar arrays are tethered whenever possible. Provide fault tolerance against inadvertent commanding of solar array deployment.	1E	3	EWR 127-1, Sections 3A.2.4.1, 3.14.3, 6.4.4, 6.14	Open.
1.7	Tipping of GSE racks, shifting of unsecured GSE	Improper design; Inadequate, or failure to follow, procedures	Damage to hardware, personnel injury	3B	2	Ensure tipping analysis/ center-of-gravity analysis/ seismic analysis of racks is performed. GSE that can be tipped should have a widened base (outriggers) or warning labels. Equipment should have locking castors or be adequately restrained. Review all handling procedures.	3D	3	EWR 127-1, Sections 3A.2.5, 3.6, 6.4.4	Open.
1.8	Tripping over protruding equipment	Improper design; Inadequate, or failure to follow, procedures	Damage to hardware, personnel injury	3B	2	Ensure protruding hardware is adequately marked; protect cables from personnel traffic. Review all handling procedures.	3D	3	EWR 127-1, Sections 3A.2.5, 3.6, 6.4.4, 6.5.3	Open.

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Collision
Prepared by: Hernandez Engineering, Inc.

Date: 04/14/99
Page: B-5

CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
1.9	Failure of lifting equipment, dollies, etc.	Defects in design, materials and/or assembly; Electrical/ electronic failure; Inadequate or failure to follow procedures	Damage to hardware, severe personnel injury, or possible death	1C	1	Design handling equipment to EWR 127-1. Conduct a stress analysis, proof testing and inspection of lifting equipment, dollies, etc in accordance with EWR 127-1. Use equipment only for intended functions. Review all handling procedures.	1E	3	EWR 127-1, Sections 3A.2.5, 3.6, 6.4.4, 6.14	Open.
1.10	Improper use of scaffolding, and accessing of satellite	Defects in design, materials and/or assembly; Inadequate or failure to follow procedures	Damage to hardware, severe personnel injury, or possible death	1B	1	Verify scaffolding is in accordance with EWR 127-1. Verify personnel are properly trained to use scaffolding. Review all handling procedures.	1D	2	EWR 127-1, Sections 3A.2.5.1.6, 3.6, 6.4.4	Open.

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Pinch Points
Prepared by: Hernandez Engineering, Inc.

Date: 04/14/99
Page: B-6

CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
2.1	Improper handling during release, activation or deployment of solar arrays	Inadequate, or failure to follow, procedure	Personnel injury	3D	3	Review procedure to ensure precautions are taken to avoid pinching. Procedures should include steps to ensure solar arrays are pinned whenever possible.	3E	3	EWR 127-1, Sections 1.5.4.5, 6.4.4	Open.
2.2	Improper removal of Access panels	Inadequate, or failure to follow, procedure	Personnel injury	3C	2	Review procedure to ensure precautions are taken to avoid pinching.	3E	3	EWR 127-1, Sections 1.5.4.5, 6.4.4	Closed. HESSI does not contain any access panels.
2.3	Improper installation and integration of hardware (includes connecting/ disconnecting hoses)	Inadequate, or failure to follow, procedure	Personnel injury	3C	2	Review procedure to ensure precautions are taken to avoid pinching.	3E	3	EWR 127-1, Sections 1.5.4.5, 6.4.4	Open.
2.4	Inadvertent activation of shudders	Defects in design, materials and/or assembly; Electrical/ electronic failure; Inadequate or failure to follow procedures	Damage to hardware, personnel injury	2D	2	Provide fault tolerance against inadvertent commanding of shudders; Review procedures to ensure precautions are taken to avoid pinching	2E	3	EWR 127-1, Sections 1.5.4.5, 6.4.4	Open.

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Explosion/Implosion
Prepared by: Hernandez Engineering, Inc.

Date: 04/14/99
Page: B-7

CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
3.1	Failure of battery cells to contain cell pressure	Defects in design, materials and/or assembly; Inadequate, or failure to follow, procedures for charging and reconditioning	Damage to hardware, personnel injury, possible death, release of hazardous materials	1C	1	Design pressure components to MIL-STD-1522A. Leak-before-burst Analysis. Monitor and control battery pressure and temperature during charge and reconditioning.	1E	3	EWR 127-1, Sections 3.12.1, 3.14.3.3, 6.4.4, Appendix 3C	Open.
3.2	Failure of purge equipment to contain pressure	Defects in design, materials and/or assembly; Inadequate or failure to follow procedures	Damage to hardware, personnel injury, possible death, release of hazardous materials	1D	2	Design pressure components to MIL-STD-1522A. Leak-before-burst Analysis. Insure any pressurized bottles meet DOT and CGA requirements.	1E	3	EWR 127-1, Sections 3.11.1, 6.4.4, Appendix 3C	Open.
3.3	Failure of Cryostat to hold a vacuum	Defects in design, materials and/or assembly; Inadequate or failure to follow procedures	Damage to hardware, severe personnel injury, possible death	1D	2	Design pressure components to MIL-STD-1522A.	1E	3	EWR 127-1, Sections 3.12.5, 6.4.4, Appendix 3C	Open.
3.4	Failure of Cryocooler to contain pressure	Defects in design, materials and/or assembly; Inadequate or failure to follow procedures	Damage to hardware, personnel injury, possible death, release of hazardous materials	1D	2	Design pressure components to MIL-STD-1522A. Leak-before-burst Analysis. Insure any pressurized bottles meet DOT and CGA requirements.	1E	3	EWR 127-1, Sections 3.11.1, 6.4.4, Appendix 3C	Open.

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Hazardous Materials
Prepared by: Hernandez Engineering, Inc.

Date: 04/14/99
Page: B-8

CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
4.1	Release of hazardous materials from batteries	Defects in design, materials and/or assembly; Inadequate, or failure to follow, procedures for charging and reconditioning	Unpleasant odors, potentially acute and systemic toxic health effects for personnel leading to severe illness or death	1C	2	Use sealed cells and design to MIL-STD-1522A.	1E	3	EWR 127-1, Sections 3.12.1, 3.14.3.3, 6.4.4, 6.10	Open.
4.2	Failure to properly contain and handle hazardous cleaning agents, lubricants, staking compounds, and solar array repair kit materials.	Inadequate, or failure to follow procedures; Inadequate containers or handling; Failure to wear proper protective gear	Unpleasant odors, potentially acute and systemic toxic health effects for personnel leading to severe illness	2B	1	Use properly labeled and approved storage containers. Personnel handling hazardous material will wear appropriate protective gear as prescribed in the MSDS and EWR 127-1. Personnel handling hazardous material will follow MSDS handling instructions (such as using a vent hood when mixing epoxies). Personnel will follow spill procedures as prescribed in the MSDS.	1D	2	EWR 127-1, Sections 6.4.4, 6.5.2, 6.10, 3.10	Open.
4.2	Inhalation of Beryllium combustible products	Inadequate, or failure to follow procedures; Inadvertent combustion of Beryllium windows	Potentially chronic toxic health effects for personnel leading to severe illness	1E	3	Personnel handling Beryllium windows should follow MSDS handling instructions and only handle solid samples. Prevent combustion.	2E	3	EWR 127-1, Sections 6.4.4, 3.10	Open.

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Non-ionizing/Ionizing Radiation
Prepared by: Hernandez Engineering, Inc.

Date: 04/14/99
Page: B-9

CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
5.1	Hazardous levels of RF radiation due to inadvertent RF transmission	Electrical/electronic failure; Inadequate or failure to follow procedures	Interference with other electronics, injury to personnel	1D	2	Use hat couplers and establish keep out zones. Ensure controls are implemented to minimize probability of inadvertent turn on.	1E	3	EWR 127-1, Sections 6.4.4, 6.8, 6.14, 6.14.3	Open.
5.2	Hazardous levels of RF radiation due to leakage from hat coupler during RF transmission	Defects in design, materials and/or assembly; Inadequate or failure to follow procedures	Interference with other electronics, injury to personnel	1D	2	Measure EMI leakage from the hat coupler.	1E	3	EWR 127-1, Sections 6.4.4, 6.8	Open.
5.3	Exposure to hazardous laser emissions from calibration laser.	Inadequate or failure to follow procedures	Damage to hardware, severe personnel injury	2D	2	Review procedures to ensure precautions are taken to avoid laser exposure.	3D	3	EWR 127-1, Sections 3.8.2	Open.
5.4	Exposure to hazardous levels of Ionizing radiation due to leakage from detector monitoring device (Cesium - 137)	Failure of containment.	severe personnel injury	2C	2	Use a minimum amount of Cecium-137 to meet system requirements.	2E	3	EWR 127-1, Sections 3.9	Open.
5.5	Safety Critical Component failure due to EMI from Torque Rods	Defects in design or assembly; Inadequate, or failure to follow procedures	Damage to hardware, minor personnel injury	3D	3	Limit intensity of EMI produced. Ensure all components are suitably shielded from EMI.	3E	3	EWR 127-1, Sections 6.4.4, 6.8	Open.

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Extreme Temperatures
Prepared by: Hernandez Engineering, Inc.

Date: 04/14/99
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CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
6.1	Fire and exposure to hot surfaces due to heaters failed on	Electrical/electronic failure; Defects in design, materials and/or assembly	Damage to hardware, personnel injury, possible death (flammable only)	1D	2	Thermal analysis for heater failed on condition. Use thermostats to protect heaters that can overheat.	1E	3	EWR 127-1, Sections 3A.2.4.1, 3.14.3, 6.14	Open.
6.2	Fire and exposure to hot surfaces resulting from Current overloads	Electrical/electronic failure; Defects in design, materials and/or assembly	Damage to hardware, personnel injury, possible death (flammable only)	1D	2	Ensure proper fusing and wire size.	1E	3	EWR 127-1, Sections 3A.2.4.1, 3.14.3, 6.14	Open.
6.3	Hot surfaces (battery, solar array lamp array, radiators)	Inadequate or failure to follow procedures	Damage to hardware, personnel injury, possible death (flammable only)	1D	2	Ensure hot surfaces are inaccessible during normal operations. Insure procedures provide cautions/warning and use of PPE (as appropriate) when contact with hot surfaces may be possible.	1E	3	EWR 127-1, Section 6.4.4	Open.
6.4	Frostbite or cryogenic burns due to Exposure to cryogenics (N_2, He)	Inadequate or failure to follow procedures (including the use of proper Personnel Protective Equipment (PPE))	Personnel injury	2C	2	Train personnel to safely work with cryogens. Assure personnel use appropriate PPE.	2E	3	EWR 127-1, Sections 6.4.4, 6.5.2, 6.11.4.7	Open.

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Asphyxiation
Prepared by: Hernandez Engineering, Inc.

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CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
7.1	Asphyxiation due to Exposure to the nitrogen purge atmosphere	Inadequate or failure to follow procedures (including the use of proper Personnel Protective Equipment (PPE)); Inadequate ventilation	Death	1C	1	Review procedures to insure oxygen levels are measured and above 19.5 % where personnel work in confined space with the nitrogen purges. Train personnel about the hazards of asphyxiation	1E	3	EWR 127-1, Sections 6.4.4, 6.5.2, 6.12.4.3	Open.

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Electro-Magnetic Interference (EMI)
Prepared by: Hernandez Engineering, Inc.

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CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
8.1	Electrical discharge/shock resulting from exposure to high voltage sources in instrument	Defects in design; Inadequate or failure to follow procedures	Personnel injury, possible death	1C	1	Review procedures to insure power is removed when personnel work in the vicinity of high voltages. Contain high voltage sources and assure proper grounding.	1E	3	EWR 127-1, Sections 3A.2.4.1.1, 3A.2.5.3.3, 3.14, 6.4.4	Open.
8.2	Electrical discharge/shock resulting from exposure to high voltage sources in EGSE	Defects in design; Inadequate or failure to follow procedures	Personnel injury, possible death	1C	1	Label electrical switch and fuse boxes to show voltage present, fuse capacity and equipment that controls and is controlled by high voltage circuits. Contain high voltage sources and assure proper grounding.	1E	3	EWR 127-1, Sections 3A.2.5.3.3, 3.14.1, 3.14.2, 6.4.4	Open.
8.3	Electrical discharge/shock resulting from solar arrays inadvertently generate power	Inadequate or failure to follow procedures	Personnel injury, possible death	1D	2	Maintain covers over solar arrays to avoid exposure to light.	1E	3	EWR 127-1, Sections 3.14, 6.4.4	Open.
8.4	Electrical discharge/shock resulting from improper grounding	Defects in design or assembly	Personnel injury, possible death	1C	1	Verify grounding scheme to ensure all equipment (including structure) are bonded/grounded via single point ground.	1E	3	EWR 127-1, Sections 3A.2.4.1.1, 3A.2.5.3.3, 3.14	Open.

HESSI PRELIMINARY HAZARD ANALYSIS

Project: High Energy Solar Spectroscopic Imager
Hazard Category: Electro-Magnetic Interference (EMI)
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CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2	REFERENCES	STATUS
8.5	Electrical discharge/shock resulting from mismating of connectors	Defects in design or assembly; Inadequate, or failure to follow procedures	Personnel injury, possible death	1C	1	Use unique connectors for potentially hazardous connections (size, cable length, lock/keyed, labels, etc.). Use scoop-proof connectors to prevent partial mismates. Review procedures to ensure connectors are unpowered, for mating.	1E	3	EWR 127-1, Sections 3A.2.4.1.1, 3A.2.5.3.3, 6.4.4	Open.
8.6	Electrical discharge/shock resulting from Electro-Static Discharge (ESD)	Use of static producing materials and/or low humidity; Failure to follow procedures	Damage to hardware, minor personnel injury	3D	3	Limit use of static producing material. Ensure grounding/bonding of static producing materials. GSE (including MGSE) and personnel will be properly grounded.	3E	3	EWR 127-1, Sections 6.4.4, 6.14	Open.