HESSI Mission Integration & Test Plan

HSI_MIT_001C
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Written By:	_________________________ Jay Trimble, UCB HESSI I & T Engineer	Date:_____________
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Approval:	______________________________ Dave Curtis, UCB HESSI System Engineer	Date:_____________

CONTENTS

Purpose & Scope

This purpose of this document is to facilitate a working process within the HESSI team for the development of mission integration and test plans, and to document schedules, procedures, constraints, requirements and equipment specifications necessary for a successful integration and test phase for HESSI. Mission I & T refers to integration and test activities which take place following the delivery of each subsystem to UCB with all planned subsystem-level tests completed.

Applicable Documents

General Environmental Verification Specification for STS & ELV Payloads, Subsystem and Components	GEVS-SE-REV A
HESSI Performance Assurance Implementation Plan	NAS5-98033
HESSI Mission Requirements	HSI-SYS-021B
HESSI Spacecraft Bus Integration and Test Plan (Spectrum Astro)	Spectrum Astro Contract No. PPB005884
Spacecraft Bus – Spectrometer ICD	HSI-SYS-015E
HESSI Spectrometer ICD Drawing	HSI_SYS_014D
Spacecraft Bus – Imager ICD	HSI-SYS-016C
HESSI-PE82-022b - Imaging System & GSE - Product Specification and & HESSI Interfaces	HSI_IMG_001A
Spacecraft – RAS ICD	HSI-SYS-017D
HESSI RAS ICD Drawing	HSI_SYS_018A
Spacecraft Bus – IDPU ICD	HSI-SYS-001D
HESSI Imager ICD Drawing	HSI_SYS_009A
HESSI Harness Diagram	HSI_SYS_005H
HESSI Spacecraft to I&T IGSE (SCAT) ICD	HSI_GDS_002A
ITOS to I&T IGSE (SCAT) ICD	HSI_GDS_003A
HESSI to Pegasus XL ICD	Orbital Sciences Drawing Number A70370

Level 3 Requirements

1.0 Mission I & T shall verify system functionality of the following subsystems (assumes successful testing at the subsystem level)
   - 1.1 Spacecraft Bus
   - 1.2 Spectrometer
   - 1.3 Imager & RAS
   - 1.4 IDPU

2.0 Mission I & T shall verify the following electrical and functional interfaces
   - 2.1 Imager to IDPU
   - 2.2 Spectrometer to IDPU
   - 2.3 IDPU to S/C Bus
   - 2.4 Spacecraft Bus to GDS

3.0 Mission I & T shall verify the following alignments using ring/marmon clamp as reference
   - 3.1 RAS/SAS (measurement)
   - 3.2 FSS/SAS (measurement)
   - 3.3 Imager/Spectrometer
   - 3.4 Imager/Spacecraft

4.0 Mission I & T shall verify the spacecrafts ability to function in the space environment, launch environment, and survive ground transport.

5.0 Mission I & T shall verify the spacecrafts ability to properly execute its on-orbit operations plan.

Test Flow Chart, Dependencies & Schedules

If you're viewing this document on-line, you can view the Mission I & T Schedule at:

ftp://apollo.ssl.berkeley.edu/pub/hessi/schedules/hsi_mint.mpp

You must have Microsoft Project 98 or later.

I & T Support Teams

SSL Team

Position	Name	Phone	e-mail
Spacecraft System Engineer	Dave Curtis	510 642-5998	dwc@ssl.berkeley.edu
Integration and Test Engineer	Jay Trimble	510 642-0149	jtrimble@ssl.berkeley.edu
Lead Test Conductor	Tim Quinn	510 643-8379	teq@ssl.berkeley.edu
Test Conductor	Joe Rauch-Lieba	510 642-6119	Rauch@ssl.berkeley.edu
Test Conductor	Sandy Wittenbrock	510 642-6119	Sandy@ssl.berkeley.edu
Test Conductor	TBS		
Lead Calibration	Dave Smith	510 643-1585	dsmith@ssl.berkeley.edu
Calibration	Bob Campbell	510 642-4186	Rdc@ssl.berkeley.edu
Lead Mechanical Engineer	David Pankow	510 642-1034	dpankow@ssl.berkeley.edu
Mechanical Engineer	Bob Pratt	510 643-9652	pratt@ssl.berkeley.edu

Spectrum Astro Team

Position	Name	Phone	e-mail
Spacecraft Bus System Engineer	John Jordan	602 892-8200	john.jordan@specastro.com
Spacecraft Bus Integration and Test Engineer	John Dipalma	602 892-8200	John.dipalma@specastro.com
Spacecraft Bus GSE Engineer	Jeff Jackson	602 892-8200	Jeff.jackson@specastro.com
Spacecraft Bus Electrical Engineer	Mike Matranga	602 892-8200	Mike.matranga@specastro.com

PSI Team

Position	Name	Phone	e-mail
Imager Engineer	Alex Zehnder	41 56 310 36 15	alex.zehnder@psi.ch
System Engineer	Reinhold Henneck	41 56 310 3404	Reinhold.henneck@psi.ch
Electronic Eng.	Aliko Mtchedlishvili	41 56 310 32 47	Aliko@psi.ch
Mechanical Eng.	Knud Thomsen	41 56 310 42 10	Knud.thomsen@psi.ch
Mechanical Eng.	Peter Ming	41 56 310 41 28	Peter.ming@psi.ch

GSFC Team

Position	Name	Phone	e-mail
Grid Rep	Gordon Hurford	(301) 286-4255	ghurford@pop600.gsfc.nasa.gov
Alignment	Dave Clark	301 286-0710	david.clark@gsfc.nasa.gov

Test Staffing

Single Shift Staff – TBS

Overtime Shift Staff – TBS

PSI Support

Activity	PSI Support
Transport Imager to SIF	Peter Ming
RAS/SAS/IDPU Functional Test (Pre-Integration)	Aliko, Reinhold Henneck
Install Rear Cap, Rear Cylinder, MLI Blankets	Peter Ming, Knud Thomson
Imager/Spectrometer Alignment	Alex Zehnder, Reinhold
Install RAS	Reinhold
RAS/SAS Measurements (CMM)	Alex, Reinhold
FSS/SAS Measurements	Alex
TMS	Alex
Instrument Functionals	Aliko
RAS/Imager Coalignment Verification (CMM)	Reinhold, Alex

Test Tracking/Reporting/Anomalies

Daily Meetings

During the HESSI Mission I & T phase, there shall be an I & T planning meeting at 8:00 a.m. daily. The meeting shall review spacecraft and test status, activities from the prior day and planned activities for the current days testing.

Tracking and Logging Nominal Test Operations

At the start of each test, the Test Conductor shall document the test setup and initial conditions. The Test Conductor shall keep a written log that documents test events, with a time notation for each entry. The Test Conductors written log shall supplement the ITOS logs (see below).

Subsystem Engineer Logs

Subsystem engineers shall keep logs to document running time, results of subsystem performance analysis.

ITOS Logs

TBS

Tracking System/Subsystem Operating Time

ITOS shall be used to track subsystem operating time.

Configuration Control

A configuration control system shall be in place to document and track the configuration of the spacecraft and work performed during Integration and Test. Configuration control shall include visual documentation of the spacecraft configuration using digital pictures.

Spacecraft Configuration Controlled Elements

TBS

Dealing with Anomalies

A test anomaly is any non-nominal or unexpected data or result that occurs during testing. All anomalies shall be noted in the test conductors log, and this notation shall include the time of the event, the symptoms, and a description of the test setup and any test/spacecraft configuration information that would be needed to diagnose the anomaly. Anomalies shall be classified by the following classifications according to their implications for HESSI mission performance:

1. Mission Critical – Failure can impact ability to successfully fulfill primary mission science requirements.
2. Secondary Science Impact – Failure can impact the ability to successfully fulfill secondary mission science requirements.

3. Mission Operations Impact – Failure can impact mission operations, does not endanger ability to collect science data over the lifetime of the mission but may require operational changes.
4. Secondary Impact – Failure does not impact primary mission or operations. May impact extended mission.
5. No significant impact.

PFR's

For all anomalies of class 4 or higher, the test conductor shall fill out an anomaly report using the Spacecraft Emergency Response System (SERS). If the anomaly cannot be classified in real-time, then a PFR shall be filled out for review by appropriate engineering/science teams.

Test Review Board

A Test Review Board (TRB) shall review all failure reports of class 3 or higher. The TRB shall be convened on an as-needed basis. This board shall consist of the Project Manager, System Engineer, Principal Investigator, Quality Assurance Manager, Spectrum Rep and PSI Rep, or their delegate(s). The TRB shall call in support from subsystem engineers and/or science team members on an as-needed basis. At the end of each test shift, the test conductor will complete a test report log (TRL). The TRL shall be a summary of key events that occurred during the test, and will include mention of all anomalies. The Project Manager and System Engineer shall review the TRL on a weekly basis in order to understand any programmatic implications of test results.

PFR's shall be tracked in a Database that will be available on the Web. The TRL shall also be available on the Web.

Facilities

Integration and Test Facilities at UCB

High Bay

The high bay will be used for inserting the Imager and the Spectrometer into the spacecraft bus.

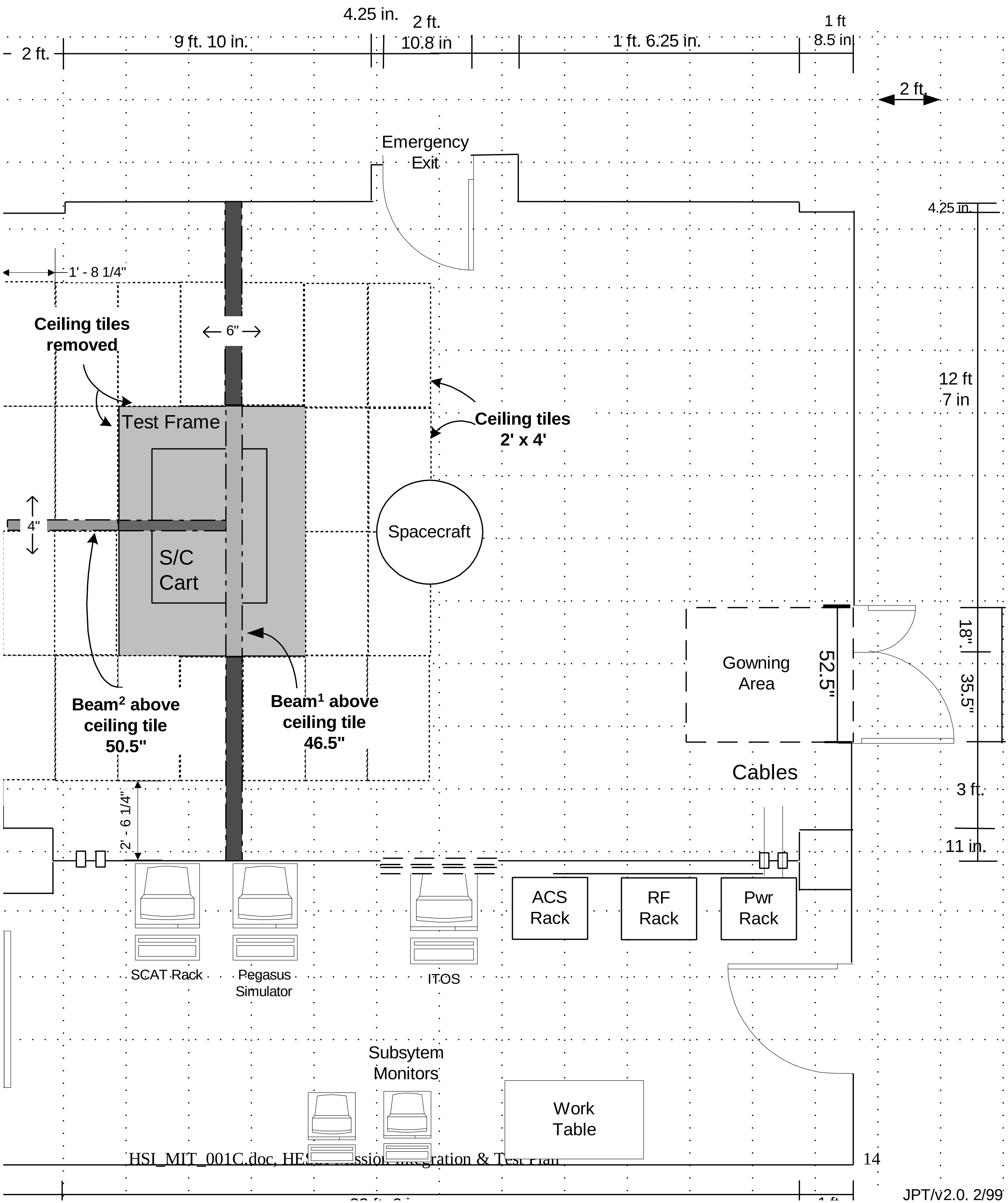
Spacecraft Integration Facility

The spacecraft integration facility (SIF) is rooms 125 and 127 in the new building at SSL. The room 125 area of the SIF consists of a clean area for spacecraft processing, a gowning area, as well as support areas for GSE (see figure on the following page). The room 127 area of the SIF will house GSE support racks and Integrated Test and Operations Systems (ITOS) workstations. Following insertion of the Imager and the Spectrometer into the spacecraft bus, the spacecraft will reside in the SIF for the duration of I & T at Berkeley.

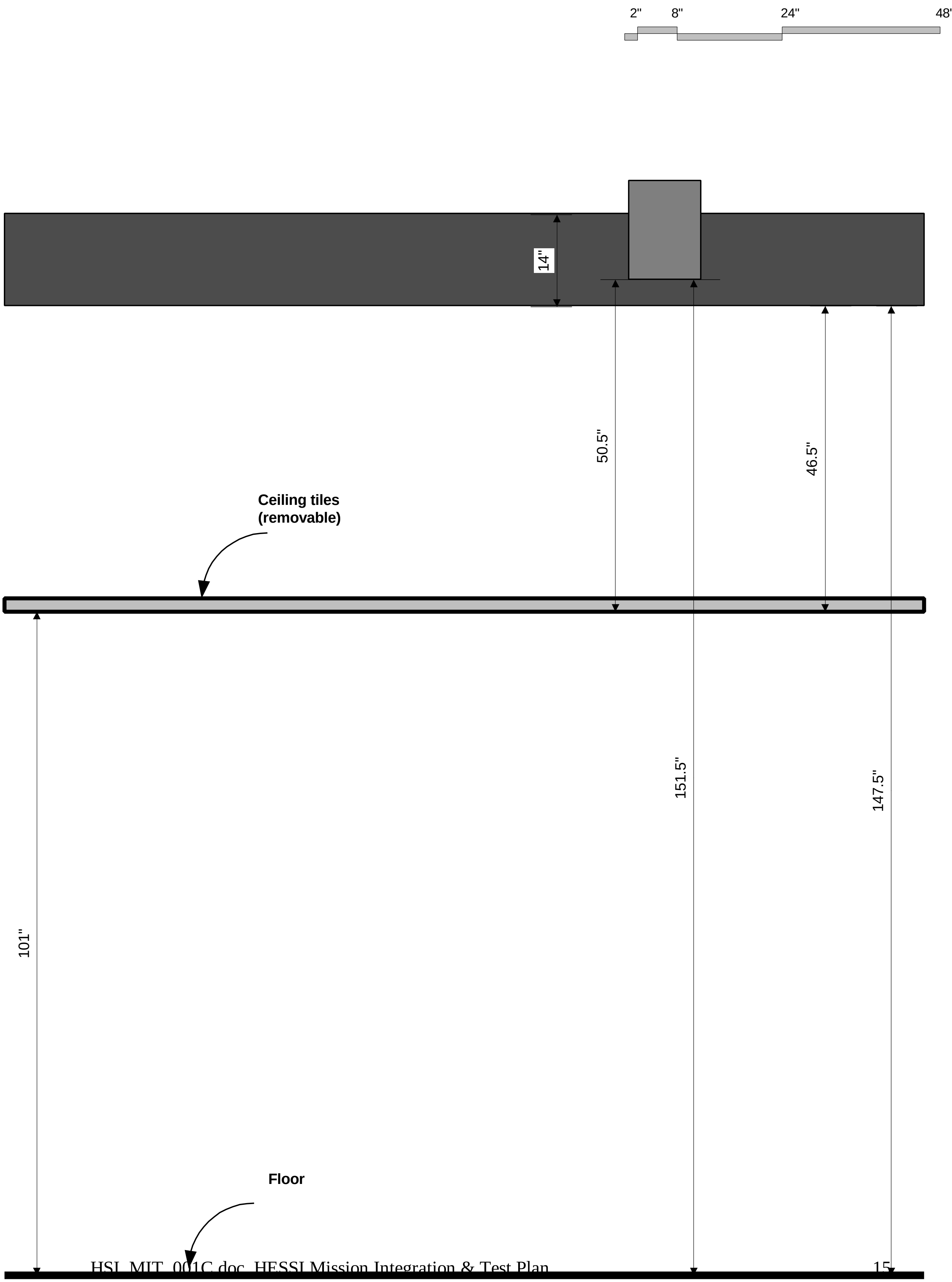
SIF Clean Area

The SIF clean requirement is class 100,000, which is driven by the RAS and SAS optics (the optics will normally be covered), and the Imager tube and Grids.

HESSI Spacecraft Integration Facility (SIF)



HESSI (SIF) Beam Heights



Handling of Radioactive Sources at UCB

TBS

Storage Area

Located adjacent to the SIF in SSL room TBD, this area will be used for storing shipping containers and other equipment.

Environmental Testing: JPL Facilities

Environmental Testing

Jet Propulsion Laboratory facilities shall be used for all environmental tests, including vibration, shock, thermal vacuum, spin balance, CG and MOI, EMI/EMC, and thermal balance.

For more information on the HESSI environmental test program see the HESSI Environmental Test Plan.

Launch Vehicle Integration: VAFB Facilities

VAFB and KSC Facilities
Testing at VAFB consists of three phases:

- Functional verifications, solar array installation and testing at NASA's facilities in building 836.
- Abbreviated functional and Pegasus mating in building 1555.
- Hotpad Testing

Facilities specifications for NASA facilities at VAFB are available in the NASA Facilties Reference Book for VAFB.

VAFB facilities drawings for buildings 836 and 1555 TBS.

Launch Vehicle Integration: KSC Facilities

Following the ferry flight from VAFB to KSC, an abbreviated functional shall be performed on the HESSI spacecraft, followed by a final pump down of the cryostat.

KSC Facilities drawings TBS.

Ground Support Equipment

MGSE

Name	Purpose	Responsibility
Imager Lifting Fixture	Lift the Imager/Spacecraft	PSI
Rotation Fixture Adapter	Structural frame interface from spacecraft to spacecraft rotation fixture	Spectrum Astro
Rotation Fixture	Holding fixture with bearings to rotate from vertical to horizontal	Spectrum Astro
Spacecraft Integration Dolly	Includes shock isolation casters.	Spectrum Astro
Spacecraft Thermal Vacuum Fixture	Holds the spacecraft in the JPL 10 foot horizontal thermal vacuum chamber	Spectrum Astro
Spacecraft Lifting Sling	Interface for lifting the spacecraft in the rotation fixture	Spectrum Astro
Spacecraft Adapter Ring (Red Ring)	Serve as interface to GSE, protect flight interface	Spectrum Astro
Spin Table Adapter	Interface from GSE red ring to mass properties instrument	Spectrum Astro
Spacecraft vibration fixture	GSE red ring allows mounting to JPL fixture through 24 load washers	Spectrum Astro
Spacecraft Dolly	Dolly for integration and transportation of the spacecraft.	Spectrum Astro
S/C Stand for cryostat installation	Position the spacecraft for insertion of the crysotat from below	UCB – Turin
Cryostat position stand	Spectrometer installation into spacecraft	UCB - Turin
Load Cell	Load Cell for Imager mass properties hydraulic positioner	UCB - Pankow
Byrd Mobile	Position spacecraft for mating with the Pegasus	UCB borrow from GSFC
Spectrum EGSE shipping containers		Spectrum Astro
Spectrum MGSE shipping containers		Spectrum Astro
UCB EGSE shipping containers		
UCB MGSE shipping containers		
PSI EGSE shipping		

containers		
PSI MGSE shipping containers		
TBD Imager shipping container(s)		
Hot Pad Clean Tent	Fairing to protect the spacecraft from weather conditions at the hot pad – use at VAFB, KSC. Buy two, have one at KSC, one at VAFB. Should not need to fly on the L-1011.	Borrow from GSFC, requested through LSSP

EGSE

Label each piece of GSE with reference codes?

UCB EGSE List

Name	Size	UCB	JPL	VAFB 836	VAFB 1555	VAFB HP	KSC	Power Requirements	Comments
Spectrometer EGSE									
LN2 Cart		x	x						
		x	x						
LN2 Control Rack		x	x						
Cryostat Vacuum Pump/ion gauge GSE	19"W x 28"L x 40"H	x	x	x	x	x	x		
Cryostat Vacuum Pump Chiller	18"W x 30"L x 42"H					x	x		
Faraday Cage for Cryostat pump and chiller	24"W x 38"L x 45"H					x	x		Required for close proximity to the launch vehicle
Spectrometer Calibration									
X-Y Cal System		x	x						
X-Y Cal Electronics		x	x						
Image Generator		x							
IDPU	Uses S/C Bus GSE								
PSI Imager									
TMS Stand	TMS needs a space that is 146"x 55"x 87"	x	x	x					
TMS Control Computer	IBM ThinkPad 770	x	x	x					
TMS LED Driver Box	12" x 8" x 6"	x	x	x					Box with cable to imager and a serial link to computer. Box goes near the spacecraft. Assume 1 ft. long x 1 ft. wide.

							Box switches laser diodes on and off. Box has coax cable going to the computer.
220V Transformer	TBS	x	x	x			
X – Y Camera Control Box	19.7” x 15.8” x 7.9”	x	x	x			
Coordinate Measurement Machine		x	x	x			

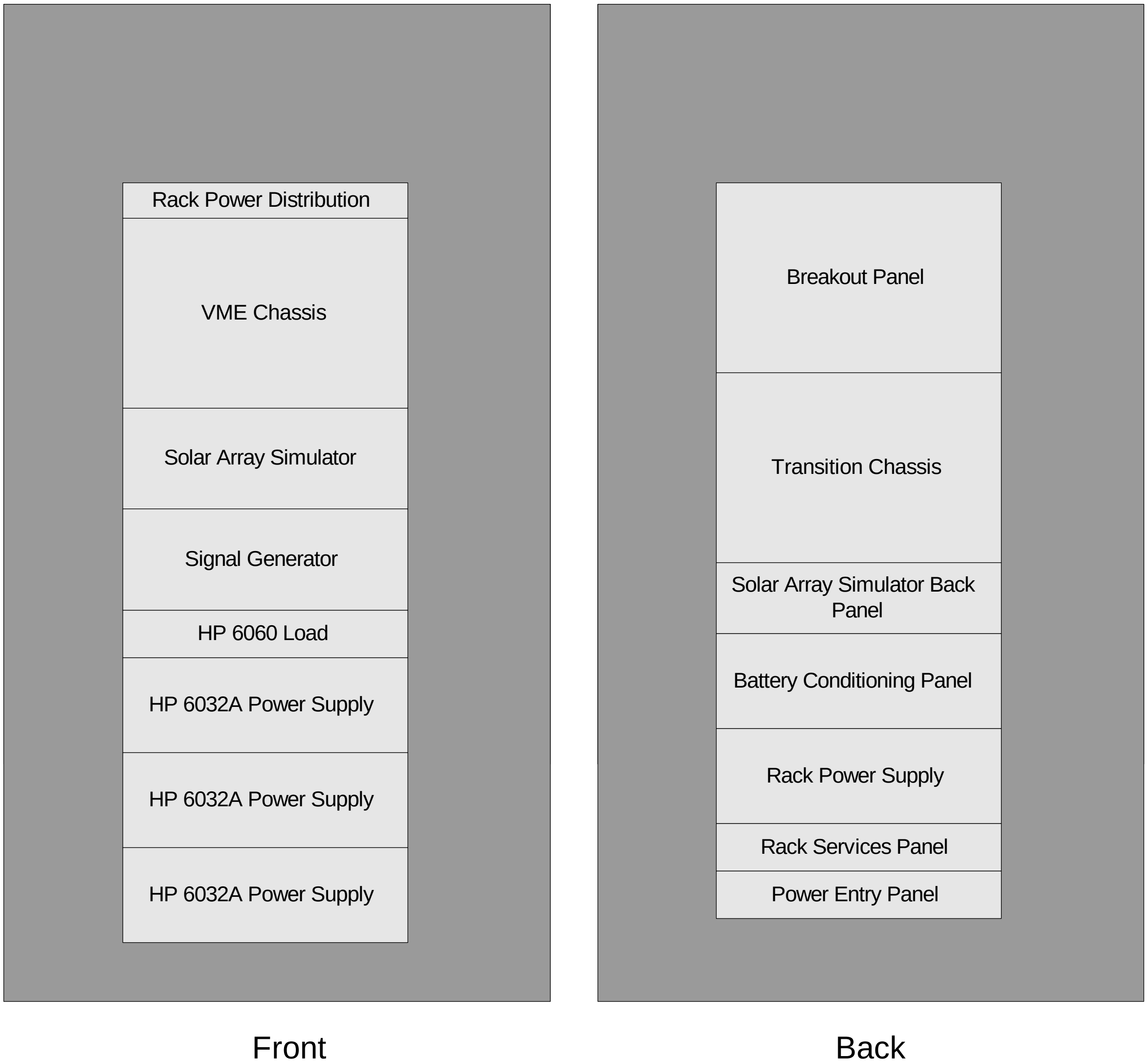
Spacecraft Bus EGSE

The Spectrum EGSE is used in all phases of Mission I & T, including UCB, JPL, VAFB and KSC Testing.

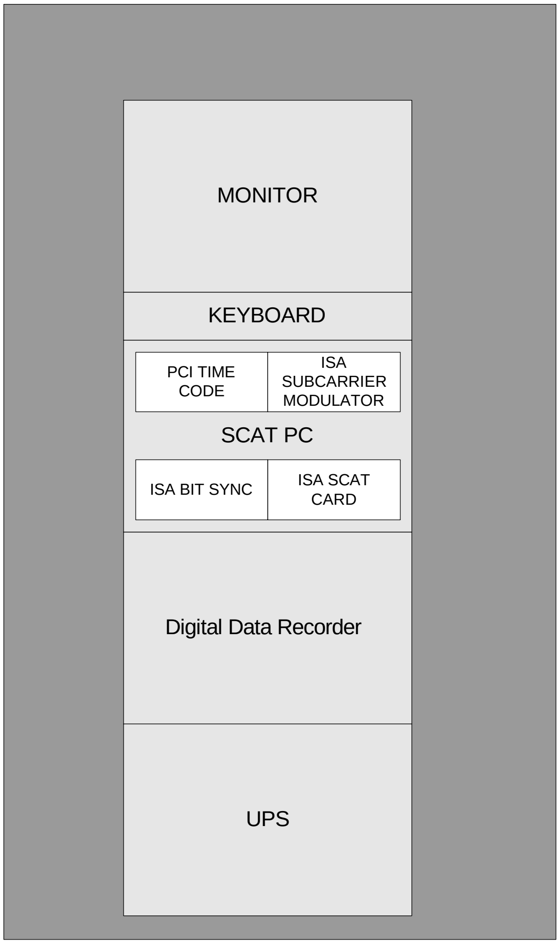
Name	Size	UCB	JPL	VAFB 836 1555 HP	KSC	Power (W)	Comments
Bus EGSE							
Power & Signal Rack		x	x	x x x	x		
-- S/C Power Supplies						2500	
-- Electronic Load						150	
-- VME						250	
-- SIG GEN						200	
-- Rack 28V Power						100	
-- Solar Array Sim						250	
Total						3450	
Command & Telemetry Rack							
--MONITOR						200	
--CPU						200	
--DDR						400	
--UPS						50	
Total						850	
COMPUTERS							
-- ITOS & P&S PC						800	
Battery Cooler		x	x	x x x	x	1300	

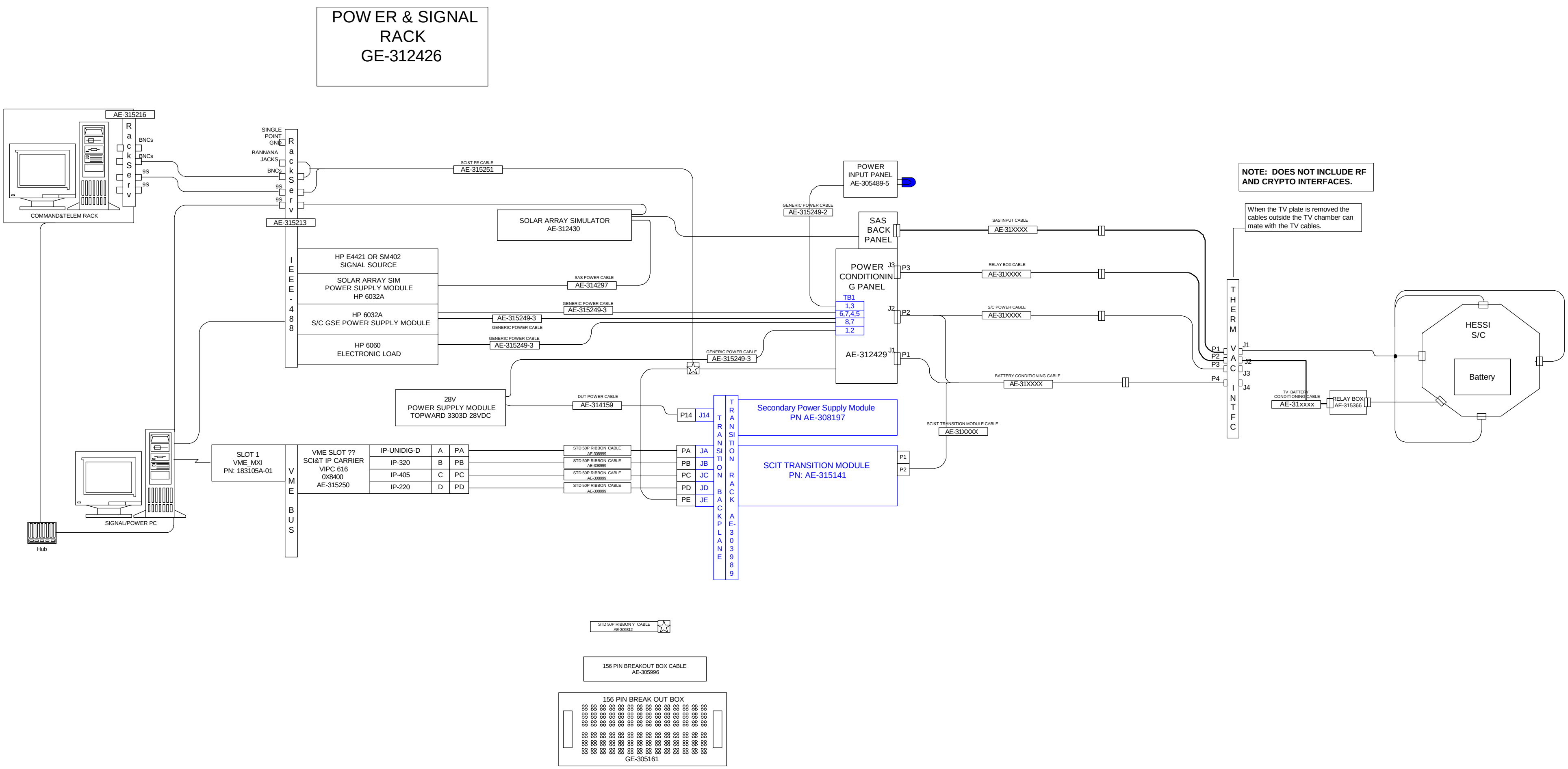
Spectrum Equipment racks are 22.5” wide x 38.5” deep x 77” tall.

Power Rack


Rack Power Distribution
VME Chassis
Solar Array Simulator
Signal Generator
HP 6060 Load
HP 6032A Power Supply
HP 6032A Power Supply
HP 6032A Power Supply
Breakout Panel
Transition Chassis
Solar Array Simulator Back Panel
Battery Conditioning Panel
Rack Power Supply
Rack Services Panel
Power Entry Panel
Front
Back

SCAT Rack


MONITOR
KEYBOARD
PCI TIME CODE
ISA SUBCARRIER MODULATOR
SCAT PC
ISA BIT SYNC
ISA SCAT CARD
Digital Data Recorder
UPS


POWER & SIGNAL RACK
GE-312426
NOTE: DOES NOT INCLUDE RF AND CRYPTO INTERFACES.
When the TV plate is removed the cables outside the TV chamber can mate with the TV cables.
COMMAND&TELEM RACK
AE-315216
AE-315213
AE-315251
POWER INPUT PANEL
AE-305489-5
SOLAR ARRAY SIMULATOR
AE-312430
SAS BACK PANEL
POWER CONDITIONING PANEL
AE-312429
HP E4421 OR SM402 SIGNAL SOURCE
SOLAR ARRAY SIM POWER SUPPLY MODULE HP 6032A
HP 6032A S/C GSE POWER SUPPLY MODULE
HP 6060 ELECTRONIC LOAD
28V POWER SUPPLY MODULE TOPWARD 3303D 28VDC
AE-314159
AE-314297
AE-315249-3
AE-315249-2
Secondary Power Supply Module
PN AE-308197
SCIT TRANSITION MODULE
PN: AE-315141
SLOT 1
VME_MXI
PN: 183105A-01
VME SLOT ??
SCI&T IP CARRIER
VIPC 616
0X8400
AE-315250
IP-UNIDIG-D
IP-320
IP-405
IP-220
SIGNAL/POWER PC
Hub
HESSI S/C
Battery
RELAY BOX
AE-315366
AE-31XXXX
STD 50P RIBBON Y CABLE
AE-309312
156 PIN BREAKOUT BOX CABLE
AE-305996
156 PIN BREAK OUT BOX
GE-305161

Test Verification Prior to Delivery to UCB

Spacecraft Bus

The following tests, to be performed by Spectrum Astro on the Spacecraft Bus prior to delivery to UCB, shall be verified to be completed before mission I & T begins:

- ❑ Modal Tap Tests
- ❑ EPS Test
- ❑ CDHS Test
- ❑ Instrument Interface Test
- ❑ Solar Array wing installation, IAD, first motion, full deploy, removal
- ❑ ACS Test
- ❑ Telecom test
- ❑ Bus Functional Test

Imager

The following tests, to be performed by PSI on the Imager prior to delivery to UCB, shall be verified to be completed before mission I & T begins:

- ❑ TMS Test
- ❑ Gridlet tests on each subcollimator using Nal detectors
- ❑ Relative co-alignment among SAS detectors and TMS using a heliostat
- ❑ Correlation of grid trays optical prism (TBD by SSL) to grid tray fiducials used by Leitz LT(D) 500 laser tracker
- ❑ ADP interface test using EGSE
- ❑ RAS/SAS functional tests
- ❑ *Assembled Grid Tray Vibration and Thermal Vacuum Testing…TBS*
- ❑ Imager Vibration Testing (modal survey, random, and sine burst)
- ❑ Imager Thermal Vacuum or thermal testing…TBS
- ❑ ADP & RAS vibration and thermal vacuum sequence
- ❑ Subsystem operating time accrued

Spectrometer

- ❑ Vibration
- ❑ Thermal Vacuum
- ❑ Functional
- ❑ Calibration
- ❑ Mass Verification
- ❑ Subsystem operating time accrued

IDPU

- ❑ Vibration
- ❑ Thermal Vacuum
- ❑ EMC (CE/CS)
- ❑ Functional
- ❑ Mass Properties

- ❑ Subsystem operating time accrued

Tests

Test Matrix

HESSI Mission I & T Overview							
Test	**Test Spec Ref. Code**	**UCB**	**JPL**	**VAFB 836**	**VAFB 1555**	**VAFB Hot Pa**
Full Bus Functional	CPT_Bus	1	2	1		
Abbreviated Bus Functional	LPT_Bus	1	2	1	1	1
Imager/Spectrometer Alignment	MECH_Img/Spec_Align	1				
RAS/SAS Measurement	MECH_Img_RAS/SASMeas	1	1			
FSS/SAS Measurement	MECH_SC/Img_FSS/SASMeas	1	1			
IDPU Functional Test	CPT_IDPU	1				
IDPU Bus Interface Test	IIT_Bus/IDPU	1				
IDPU/Imager I/F Test	IIT_IDPU/Img	1				
IDPU/Spectrometer I/F Test	IIT_Spec/Img	1				
End-to-End Image Generation	SFT_SC_ImageGen	1				
Magnetic Self Compatibility	CPT_SC_MagSelf	2				
Spectrometer Functional Electrical	CPT_Spec_Elec	1				
Spectrometer Functional Mechanical Thermal	CPT_Spec_MechTherm	1				
Imager/RAS Functional	CPT_ImgRas	1				
Spectrometer Calibration	SFT_Spec_Cal	1				
TMS	SFT_Img_TMS	2	2	1		
GDS Simulations	CPT_GDS	1				
End-to-End (plugs out)	CPT_SC/GDS_EndtoEnd	1				
Backup Ground Station Compatibility	SFT-SC/GDS_BUCompat	1				
Spectrometer Short Functional	LPT_Spec	1	3	1		
Imager Short Functional	LPT_Imager	1	3	1		
Solar Array Illumination	IIT_SolarArrays_Illumination		1	1		
Solar Array First Motion	IIT_SolarArrays_FirstMotion		3	1		
EMI/EMC	SFT_SC_EMI/EMC		1			
Vibration	SFT_SC_Vib		1			
Separation (shock)	SFT_SC_Sep		1			
Thermal Vacuum	SFT_SC_TV		4 cycles			

Thermal Balance	SFT_SC_ThermBal		1			
CG	SFT_SC_CG		1			
MOI	SFT_SC_MOI		1			
Spin Balance	SFT_SC_SpinBal		1			

Test Specifications

Spacecraft Alignment and Measurement Specification

1. Test Name: Spacecraft Alignment and Measurement

2. Ref. Code: I&T-Img-AlignMeas

3. Point of Contact: Jay Trimble/David Pankow

4. System: Spacecraft

5. Subsystem: Imager/Spectrometer

6. Test Duration: 2 days (alignments), 2 days (measurements), 1 day for measurement verifications after spacecraft environmental testing.

7. Contingency Time:

8. Test Description:
<Dave Clark fill in CMM use, description>

9. Test Objectives:

Alignments
Imager to Spectrometer
Imager to Spacecraft

Measurements
Fine Sun Sensor to Instrument (SAS)
RAS to SAS (Imager)

10. Success Criteria:
Imager to Spectrometer Alignment concentric to the detectors to 1mm TIR, and within 1/10th deg (TBR) of the spacecraft z axis

FSS to SAS: Measuring the orientation to within 1 arcmin
RAS to SAS: Measuring the orientation to within 1 arcmin

11. Hardware Requirements:
Portable CMM
Tooling Balls
TBD Base for CMM to be provided by Berkeley
Portable PC
Theodolite
Optical cubes

12. Software Requirements:
CMM Software

Autocad

13. Facility Requirements:
Clean room with TBD clearance around the spacecraft
--SIF at UCB
--TBD at environmental testing

TBD clearance for Theodolite measurements

14. System Dependencies:
After integration and verification tests to be sure spacecraft and imager will not be separated again.

15. Staffing Requirements:
Measurements
Dave Clark, and TBD assistance

Alignments
David Pankow, Mechanical Technician, Spectrum Astro Rep

16. Notes/Comments
Spacecraft to be powered off during alignments and measurements.

How is the FSS measurement made? How are Theodolite coordinates related to CMM tooling ball coordinate measurements?

Applicable Requirements
BUS 6.7.1 Imager aligned concentric to spacecraft Z-axis to 1mm, aligned with Z-axis to ± 1 deg.
BUS 6.7.2 Spectrometer concentric with Imager to 1mm, cryocooler free piston aligned with spacecraft Y-axis to ±1deg.
BUS 6.7.3.1 RAS boresight direction 15 deg up from X-Y plane
BUS 6.7.3.2 RAS pointing stable to <1.0 arc-minute (INS-2.5.6)

INS 2.3 Alignment requirement: Telescope axis aligned to Sun direction to <0.2 degrees (INS-2.7.1)
INS-2.5.5 SAS to Grid alignment, knowledge < 3 arcsecond, stability < 1 arcsecond
BUS 2.3 Pointing Control: The spin axis shall be within 0.2 deg of the Sun center (INS-2.3)

17. Failure Implications
Re-align, re-measure, possible schedule and/or performance impacts.

Imager-RAS Alignment Test Specification

1. Test Name:	Imager - RAS alignment test
2. Ref. Code:	**Align Imager-RAS**
3. Point of Contact:	**Reinhold Henneck, Alex Zehnder, Dave Clark**
4. System:	**Instrument**
5. Subsystem:	**Imager**
6. Test Duration:	**1d**
7. Contingency Time:	

8. Test Description:

1. Starting conditions:

1.1. imager, FSS and RAS are mechanically integrated with spacecraft
1.2. CMM is ready for use and connected to its GSE
1.3. all tooling-balls (TBs) are mounted

2.Testing steps:

2.1. record ambient temperature, imager/RAS has to be at equilibrium temperature
2.2. verify that TBs are properly mounted
2.3. measure at least 5 TBs on imager front tray and compare to autonomous test results. Define imager coordinate system.
2.4. measure at least 3 TBs on imager rear tray and determine positions in imager coordinate system. Compare to autonomous test results and with TMS results.
2.5. measure all 4 TBs on RAS. Compare to autonomous test results.
2.6. measure fiducial marks on FSS. Compare to nominal.

9. Test Objectives:	a) test alignment of front tray to rear tray (twist, distance, parallelity) b) measure RAS alignment with respect to imager (mainly in roll) c) measure FSS alignment with respect to imager
10. Success Criteria:	a) RAS alignment must be within ± 10‘ in roll and pitch with nominal values, measure actual orientation to within 1 arcmin b) FSS alignment must be within ± 10‘ with nominal values, measure actual orientation to within 1 arcmin
11. Hardware Requirements:	Full imager with SAS, RAS, FSS CMM with GSE
12. Software Requirements:	software developed for CMM
13. Facility Requirements:	free access all around s/c, space for GSE (2x2 m^2)
14. System Dependencies:	CMM has been successfully tested on its own, results from preceding TMS test are available

15. Staffing Requirements:	A. Zehnder, R. Henneck
16. Notes/Comments:	accuracy of CMM: $\pm$ 30 μ for the determination of one TB center in 3D over full imager volume
17. Failure Implications:	emergency. Delay for repair, may be significant if imager/RAS have to be dismounted

IDPU Functional Test Specification

1. Test Name: HESSI IDPU Functional

2. Ref. Code: HSI-MI&T-IDPU-Func

3. Point of Contact: Dave Curtis

4. System: Instrument

5. Subsystem: IDPU

6. Test Duration: 4 hours

7. Contingency Time:

8. Test Description:

Starting condition:

1. IDPU, IPC, and CPC are mechanically integrated with spacecraft
2. IDPU is electrically mated to the spacecraft, and has completed its interface test
3. IDPU is harnessed to the IPC and CPC via the Instrument harness
4. Spacecraft is connected to the spacecraft GSE, and is ready for operations
5. All instrument power services are off.

NOTE: This test does not assume that the Spectrometer, RAS, or Imager are installed (see Section 16, note 1).

Testing steps:

1. Install the High Voltage and Actuator enable plugs in the IPC.
2. Power on and configure the spacecraft bus, if it is not already powered
   - 2.1. Verify spacecraft operating nominally via state-of-health telemetry
3. Turn on SSR science telemetry; clear SSR contents.
4. Verify that the IDPU, IPC and CPC temperatures are in their start-up ranges.
5. Turn on the Instrument Power Bus
   - 5.1. Verify Nominal SAFE mode Instrument Bus current consumption (about 7W)
   - 5.2. Verify SAFE mode instrument housekeeping on the ITOS Display; temperatures, voltages, currents, instrument mode, error and reset counts, command verification, etc. (if part of the instrument is not preset on the spacecraft, the corresponding temperature sensors should be ignored).
   - 5.3. Verify no science telemetry transmitted via the SSR
6. Data Controller Board Test:
   - 6.1. Send a trial command to the IDPU
     - 6.1.1. Verify IDPU command receipt and processing
   - 6.2. Command a diagnostic memory dump of code (PROM Image)
     - 6.2.1. Verify Diagnostic packet received by ITOS
     - 6.2.2. Verify contents
     - 6.2.3. Verify packet time-tag appears nominal (check spacecraft clock interface)
   - 6.3. Command a processor diagnostic test (checks Processor RAM, Packet RAM, and I/O)
     - 6.3.1. Verify correct response
   - 6.4. Send an IDPURESET command
     - 6.4.1. Verify IDPU processor reset counter increment
   - 6.5. Force the IDPU SAFE signal from the spacecraft active
     - 6.5.1. Verify IDPU goes to SAFE mode

6.6. Return IDPU SAFE signal to nominal
6.6.1. Verify IDPU remains in SAFE mode
6.7. Command IDPU out of SAFE mode
6.7.1. Verify IDPU out of SAFE mode
6.8. Command Instrument backup spacecraft clock source
6.8.1. Verify Monitor Rates packets continue to come periodically with correct packet collection times.
6.9. Command Nominal spacecraft clock source

7. Detector Interface / Science Telemetry Test:
7.1. Enable Monitor Rates data collection
7.1.1. Verify Monitor Rates packets collected (Only) via SSR
7.1.2. Verify Monitor Rates all zero (No counts)
7.1.3. Verify packet collection times are nominal at correct rate
7.1.4. Verify no lost packets (packet counter increments sequentially)
7.2. Enable FAST rates
7.2.1. Verify Fast Rates packets collected via SSR
7.2.2. Verify Fast Rates all zero (No counts)
7.2.3. Verify packet collection times are nominal at correct rate
7.2.4. Verify no lost packets (packet counter increments sequentially)
7.3. Enable Events
7.3.1. Verify no events packets collected via SSR
7.4. Turn on AFEs
7.4.1. Verify nominal AFE SOH telemetry (voltages/currents)
7.4.2. Verify no counts in Monitor & Fast rates, No events
7.5. Enable DIF event simulation
7.5.1. Verify event packets collected via SSR
7.5.2. Verify packet rate
7.5.3. Verify packet header format
7.5.4. Verify packet contents
7.5.5. Verify Monitor rates ?
7.6. Disable DIF event simulation

[Tests of the AFE are part of the Spectrometer functional.]

8. Particle Detector Test:
8.1. Ramp up Particle Detector HV to nominal
8.1.1. Verify a low count rate from cosmic rays (?)
8.2. Bring a TBD radiation source close to the particle detector (this step can be skipped for short functionals)
8.2.1. Verify an increase in the particle detector count rates
8.3. Remove the radiation source
8.4. Set Particle Detector threshold to zero
8.4.1. Verify particle detector counts noise
8.5. Set threshold to TBD low level
8.5.1. Verify no noise counts
8.6. Set threshold to nominal
8.7. Turn off Particle Detector HV

9. High Voltage Test:
9.1. Enable the High Voltage Supplies (all supplies set to zero)
9.1.1. Verify nominal current consumption on the HV 28V supply
9.1.2. Verify HVPS outputs remain at zero
9.2. Command each supply in turn to a low level (100V ?), then back to zero
9.2.1. Verify the correct supply increases by the nominal; amount
9.2.2. Verify the HV 28V supply current is nominal

10. Cryocooler Control Test:
10.1. Command a series of cryocooler control modes (cryocooler still powered off)
10.1.1. Verify state of health housekeeping response to each mode
10.2. Command a diagnostic Cryocooler control waveform packet for each mode

10.2.1. Verify waveform is nominal
10.3. Set the cryocooler control to zero.
11. CPC Test
11.1. Power on the Cooler Supply
11.1.1. Verify nominal (small) current consumption on Cooler service and no increase on Instrument service
11.2. CPC / Cryocooler test (requires Spectrometer attached to CPC; MOVE THIS TO SPECTROMETER FUNCTIONAL TEST ?)
11.2.1. Set the cryocooler control to a low power level (corresponding to 20W).
11.2.1.1. Verify increase in cooler power service current consumption (by about 20W).
11.2.1.2. Verify the accelerometer waveform in instrument SOH (no vibration damper)
11.2.2. Set the nominal Vibration Damper power & phase corresponding to the cooler power level and cold tip temperature
11.2.2.1. Verify nominal cooler power service increment
11.2.2.2. Verify reduced accelerometer waveform in instrument SOH
11.3. Set the cooler and damper controls to zero, and power off the cooler power service
12. Cold plate Heaters test
12.1. Enable the Cold Plate Heater Supply (100V)
12.1.1. Verify the supply comes on via the SOH telemetry
12.2. Power off the Cold Plate Heater (Further testing will be included in Spectrometer functional)
13. Imager Heater Test
13.1. Power-on the Spacecraft Switched Service to the Instrument
13.1.1. Verify switched service 28V via instrument SOH
13.2. Power on each imager heater directly in sequence (bypass the on-board control software)
13.2.1. Verify 28V on the associated heater service via instrument SOH
14. Actuator Test
14.1. Power-on the Spacecraft Switched Service to the Instrument
14.1.1. Verify switched service 28V via instrument SOH
14.2. Enable the Actuator power service
14.2.1. Verify actuator 10V supply via instrument SOH
14.3. Determine if any of the actuators are connected and may be fired; DO NOT FIRE ANY ACTUATOR WITHOUT OK FROM SYSTEM ENGINEER. CAN DAMAGE THE INSTRUMENT.
14.3.1. If any actuator OK to fire, fire the actuator (measure actuation time)
14.3.1.1. Verify actuator operation visually
14.3.1.2. Verify actuator position change via instrument SOH data
14.3.1.3. Re-stow device if necessary
14.4. Disable the Actuator power service and power-off the Switched Power service.
15. Instrument Heater Test
15.1. Power on the Instrument (IDPU) heater service
15.1.1. Verify heater service power in the instrument SOH data.

9. Test Objectives:

Verify the IDPU functionality, including:

1. All electrical interfaces to the spacecraft are functional.
1.1. Power Interfaces
1.1.1. Instrument Power
1.1.2. Cooler Power
1.1.3. IDPU Heater Power

1.1.4. Switched Services Power
1.2. Temperature Sensor Interfaces
1.2.1. IDPU
1.2.2. IPC
1.2.3. CPC
1.2.4. Spectrometer
1.2.5. RAS
1.3. Signal Interfaces
1.3.1. Serial In
1.3.2. Serial Out
1.3.3. High Speed (SSR)
1.3.4. Clock
1.3.5. Reset
1.3.6. Safe
2. Nominal Instrument state-of-health telemetry
3. Particle Detector
4. Power Controller Board:
4.1. IPC control (switches)
4.2. CPC Control
4.3. HVPS control
4.4. Actuator Control & Status
4.5. Heater Control
4.5.1. Imager Heaters
4.5.2. Cold Plate Heaters
5. Detector Interface Board Control
5.1. AFE Power Switches
5.2. Threshold DACs
5.3. Test Pulser & Internal test modes
5.4. Data Collection Modes
6. Data collection and transmission through the system

NOTE: see Section 16, note 1 and 2.

10. Success Criteria:

1. The spacecraft interface must function correctly
2. All Instrument functions must operate nominally
3. System response must meet Mission Requirements

11. Hardware Requirements:

1. IDPU, including:

1.1. IDPU VME Chassis (Including Particle Dertector)

1.2. Instrument Power Converter (IPC)

1.3. Cryo Power Converter (CPC)

2. Instrument Harnesses:
   2.1. IDPU/IPC/CPC harness
3. Spacecraft Bus, including at least:

   3.1. SEM
   3.2. Solid State Recorder
   3.3. Spacecraft Harness (including Spacecraft to Instrument harness)
   3.4. Power System (some of which may be GSE simulators)
4. Spacecraft GSE, including at least:
   4.1. Spacecraft to GSE Harness (assume taking data directly from SEM)
   4.2. Power rack
   4.3. SCAT rack
   4.4. ITOS system

12. Software Requirements:

ITOS database must include IDPU entries (commands and telemetry).

13. Facility Requirements:

14. System Dependencies:

IDPU, Spacecraft Bus, and GSE shall have previously completed individual (pre-integration) functional tests.

15. Staffing Requirements:

The following people or their delegates are required:

Dave Curtis, IDPU, System
John Jordan, Spacecraft Bus
Test Conductor (ITOS operator)
Ron Jackson, QA ?

16. Notes/Comments

1. Interfaces to the Imager, RAS, and Spectrometer (including the ADP and most of the CPC and AFE functionality) shall be tested as part of those subsystem's functional tests. Alternatively, for the Spectrometer signal interface, this can be tested using the Image Generation procedure
2. IDPU Internal Software functionality shall not be tested here (beyond that needed to check hardware functionality). Software functionality is checked in the Software Acceptance Test.

18. Failure Implications

Delay for repair.

IDPU – Spectrometer Interface Test Specification

1. **Test Name:** HESSI IDPU to Spectrometer Interface Test
2. **Ref. Code:** IIT_Spec/Img
3. **Point of Contact:** Dave Curtis
4. **System:** Instrument
5. **Subsystem:** IDPU and Spectrometer
6. **Test Duration:** 2 days
7. **Contingency Time:**

8. Test Description:

Starting condition:

6. IDPU and Spectrometer are mechanically integrated with spacecraft
7. IDPU is electrically mated to the spacecraft, and has completed its interface test
8. Spacecraft is connected to the spacecraft GSE, and is ready for operations
9. Spectrometer is mated with the spectrometer nitrogen cooling system, which is keeping the detectors cold.
10. IDPU to Spectrometer harness is mated to Cryocooler and Actuator Simulation loads and Breakout boxes, NOT to Spectrometer.
11. Actuator and High Voltage Enable plugs are installed in IPC.
12. Radiator cooling system is functional.

Testing steps:

1. Verify IDPU to Spectrometer instrument harness:
   - 1.1. Power up the spacecraft and IDPU Instrument power services.
   - 1.2. Verify IDPU is responsive
   - 1.3. Verify no voltage on Spectrometer harness in IDPU SAFE mode (power-up default)
   - 1.4. Command IDPU to provide power systems to spectrometer sequentially and verify voltage levels on harnesses and load simulators
   - 1.5. Verify Cryocooler and Actuator power supplied on command to IDPU
2. Power off IDPU, mate IDPU to Spectrometer harness to Spectrometer
3. Power on IDPU
4. Verify Spectrometer temperature sensors read appropriate levels.
5. Sequence up the cryocooler to cool the detectors down to nominal levels. Verify Cryocooler is functioning nominally. Continue testing while detectors cool. Disconnect Nitrogen cooling system.
6. Manually actuate Vacuum valve location switch and verify telemetry (cannot open vacuum valve in air).
7. Test each of the shutter actuators. Verify motion visually and via telemetry. Recage the shutters on completion.
8. Verify accelerometer. Command an accelerometer reading. May be able to see vibration due to the cryocooler. If not, may need to artificially vibrate the spacecraft by applying a low level periodic motion (TBD).
9. Power on the CSAs. Verify telemetry (no counts with HV off).
10. If the detectors are cold enough (should be), ramp up the high voltage. Verify voltage level telemetry, background counting rate.

11. Command the internal test pulser through a TBD sequence and verify telemetry
12. Wait till cold plate has reached operational temperature; set cooler to maintenance power level.
13. Verify detector noise theshold level (program thershold level via IDPU and monitor count rates).
14. With a set of calibration sources, verify system X-ray response
15. Power off cryocooler, verify operation of cold plate heaters (staying below 100K).
16. Power-down high voltages, power off IDPU.
17. Reattach and start up Nitrogen cooling system
18. Remove High Voltage and Actuator enable plugs from IPC.

9. Test Objectives:

Verify the IDPU to Spectrometer electrical interfaces function properly. This includes:

1. Harness connectivity
2. Crycooler power interface (to CPC)
3. Radiator/Cryocooler Heaters and temperature sensors
4. Cold Plate Heaters
5. Cryostat temperature sensors
6. Vacuum valve actuator
7. Shutter actuator test
8. Accelerometer test
9. CSA Power, Signals
10. Detector high voltage supplies test
11. Calibration pulser
12. Detector noise threshold
13. System X-ray response (energy, throughput)

10. Success Criteria:

1. Each interface must function correctly
2. System response must meet Mission Requirements (these will have been verified at Spectrometer functionals, but must be re-verified in the flight configuration):
   - 2.1. Noise threshold must be <20keV required, 3keV goal (SCI-1.1)
   - 2.2. Energy resolution 3keV FWHM 20keV to 1MeV Required, 0.5keV 3keV to 1MeV goal (SCI-1.2)

11. Hardware Requirements:

IDPU, including:

IDPU VME Chassis

Instrument Power Converter (IPC)

Cryo Power Converter (CPC)

5. Spectrometer, including:
   - 5.1. Cryostat Assembly
   - 5.2. Shutter Assembly
6. Instrument GSE, including:
   - 6.1. Spectrometer Nitrogen GSE
   - 6.2. Spectrometer Radiator cooling system (may be part of spacecraft GSE)
   - 6.3. Cryocooler simulation load
   - 6.4. Actuator simulation loads
   - 6.5. Breakout boxes
   - 6.6. TBD Radiation Sources
7. Instrument Harnesses:
   - 7.1. IDPU/IPC/CPC harness
   - 7.2. IDPU/Spectrometer harness
8. Spacecraft Bus, including at least:
   - 8.1. SEM

    8.2. Solid State Recorder
    8.3. Spacecraft Harness (including Spacecraft to Instrument harness)
    8.4. Power System (some of which may be GSE simulators)
9. Spacecraft GSE, including at least:
    9.1. Spacecraft to GSE Harness (assume taking data directly from SEM)
    9.2. Power rack
    9.3. SCAT rack
    9.4. ITOS system

12. Software Requirements:
ITOS database must include IDPU entries (commands and telemetry).

13. Facility Requirements:
SIF (Note radiation sources will be used, so access to SIF clean area shall be limited).

14. System Dependencies:
IDPU, Spectrometer, Spacecraft Bus, and GSE shall have previously completed individual functional tests. The "IDPU Functional" shall have been completed to verify spacecraft to IDPU interfaces.

15. Staffing Requirements:
The following people or their delegates are required:

Dave Curtis, IDPU VME
Peter Berg, IDPU Power
Paul Turin, Spectrometer
Bob Campbell (Detectors)
John Jordan, Spacecraft Bus
Test Conductor (ITOS operator)
Ron Jackson, QA ?

16. Notes/Comments

19. Failure Implications
Delay for repair. May be a significant delay if problem is inside Cryostat.

Spectrometer Electrical Functional Test Spec

1. **Test Name:** Spectrometer Functional (Electrical)

2. **Ref. Code:** CPT_Spec_Elec

3. **Point of Contact:** D. Smith

4. **System:** Instrument

5. **Subsystem:** Spectrometer

6. **Test Duration:** 3 hours

7. **Contingency Time:** 2 hours

8. Test Description:
Starting condition:
1) Spacecraft and instruments are fully integrated
2) Radiator cooling system is functional
3) Actuator and high-voltage enable plugs are installed in IPC
4) IDPU and spacecraft are powered on
5) Detectors have been brought to operating temperature by the cryocooler
6) There is no other activity around the spacecraft

Testing steps:
1) Power on the CSAs. Verify in telemetry.
2) Ramp up HV in 100 V steps for each detector, stopping each one when it reaches nominal voltage OR if the reset rate in a segment exceeds the expected value.
3) For each detector segment, verify that the reset rate remains nominal
4) For each detector segment, verify that the noise threshold meets Mission Requirements
5) For each detector segment, verify that resolution meets Mission Requirements (use the 81 keV line of Ba-133 and the 1.1 and 1.3 MeV lines of Co-60; the data for 5) and 6) may be taken simultaneously).
6) For each detector segment, verify that the detector active volume remains nominal (using the Co-60 source at 0.5 m from the spacecraft in the +/-x and +/- y directions). Expected count rates will be prepared in advance.

9. Test Objectives:
Verify that all 18 detector segments are functioning in a way that
1) Meets Mission Requirements, and
2) Indicates no serious degradation since the last spectrometer functional test

10. Success Criteria:

Each detector segment meets:
1) Noise threshold per requirement SCI-1.1 AND not worse than the last functional by an amount TBD
2) Resolution per requirement SCI-1.2 AND not worse than the last functional by an amount TBD
3) Detector active volume not worse than the last functional by an amount TBD

The baselines for the very first spectrometer functional will be taken from spectrometer subsystem tests.

11. Hardware Requirements:

1) Spacecraft integrated with IDPU and spectrometer
2) Instrument GSE, including:
   2.1) Spectrometer radiator cooling system
   2.2) Calibrated 100 uCi Ba-133 and Co-60 sources
   3.3) Source stand, yardstick and level for source placement
3) Spacecraft GSE, including:
   3.1) Spacecraft to GSE harness
   3.2) Power rack
   3.3) SCAT rack
   3.4) ITOS system

12. Software Requirements:

1) Realtime display of instrument housekeeping data (temperatures, voltages, reset rate)
2) Realtime acquisition and display of spectra
3) Saving of spectra for analysis offline

13. Facility Requirements:

14. System Dependencies:

Spacecraft, IDPU, and GSE shall have passed functional tests since the last change in condition (environmental test, transport, etc.)

15. Staffing Requirements:

The following people or their delegates are required:
Bob Campbell (detectors)
Test Conductor (ITOS operator)

16. Notes/Comments

11. Failure Implications

Failure to meet mission requirements may result in a significant delay to swap out or repair a detector.

Continual degradation of a detector which could be expected to imply that the detector would fail to meet mission requirements within the first year on orbit, even if mission requirements are currently met, may result in a significant delay to swap out or repair a detector.

Minor failures to match the results of a previous functional may result in a change in operating voltage or other minor adjustments.

Spectrometer Mechanical Thermal Functional

1. **Test Name:** Spectrometer Functional (Mechanical/Thermal)

2. **Ref. Code:** CPT_Spec_MechTherm

3. **Point of Contact:** P. Turin

4. **System:** Instrument

5. **Subsystem:** Spectrometer

6. **Test Duration:** 1.5 days

7. **Contingency Time:** 0.5 days

8. **Test Description:**

Starting condition:
1) Spacecraft and instruments are fully integrated
2) Radiator cooling system is functional
3) Actuator and HV enable plugs installed in IPC
4) IDPU and spacecraft are powered on

Testing steps:
1) Pump down cryostat, turn off pump, turn on ion gauge.
2) Turn on coldplate heaters for beginning of cooldown cycle; measure a temperature change of at least TBD degrees.
3) Perform a flight-like structured cooldown overnight verify temperature profile and monitor vibration levels.
4) Leak-check cryostat by ion gauge measurment after cooldown.
5) Electrical continuity test of the one-shot valve actuator.
6) Operational test of the shutter actuators (including caging and override SMAs). Monitor both visually and in telemetry.
7) Turn on radiator heaters, measure a temperature change of at least TBD degrees, turn off.

9. **Test Objectives:**

Verify that all spectrometer thermal and
mechanical systems are functioning normally

10. **Success Criteria:**
1) Coldplate temperature reaches expected value in expected time.
2) Cryocooler vibration levels not more than TBD and not significantly worse than baseline.
3) Radiator and coldplate heaters produce expected change in temperature in expected time (prediction ready in advance).
4) Cryostat leakage rate less than TBD/day.
5) One-shot valve actuator circuit intact.6) All shutter-actuator SMAs activate in the expected time.

11. **Hardware Requirements:**
1) Spacecraft integrated with IDPU and spectrometer

2) Spectrometer GSE:
   2.1) radiator cooling system
   2.2) vacuum GSE
   2.3) ion gauge GSE
3) Spacecraft GSE, including:
   3.1) Spacecraft to GSE harness
   3.2) Power rack
   3.3) SCAT rack
   3.4) ITOS system

12. Software Requirements:
Realtime display of instrument housekeeping data (temperatures, voltages, status bits)

13. Facility Requirements:

14. System Dependencies:

15. Staffing Requirements:
The following people or their delegates are required:
Paul Turin (spectrometer)
Test Conductor (ITOS operator)

16. Notes/Comments
If the coldplate and detectors are already cold from the LN2 loop, step 2 will be skipped and step 3 will take less time.

Steps 5, 6, and 7 may take place during step 3.

17. Failure Implications
Failure of the cooler or coldplate heaters may result in a significant delay (weeks) to open the cryostat and repair or replace the affected components.

Failure of the shutter actuator systems will require removing the cryostat from the spacecraft for repairs (days).

Failure of the radiator heaters might be fixed in hours.

Certain failure modes of the shutter actuators might be accepted without repair if the failures occurred near launch time.

RAS Functional Test Specification

1. Test Name: **Electronics Functional Test RAS**
2. Ref. Code: Func-RAS
3. Point of Contact: Reinhold Henneck
4. System: Instrument
5. Subsystem: Imager
6. Test Duration: 4 h
7. Contingency Time:
8. Test Description:

3. Starting conditions:

3.1.RAS and IDPU are mechanically integrated with spacecraft, RAS baffle is covered with LED cover, LED is connected to LED driver
3.2.IDPU is electrically mated to s/c and has completed its interface test
3.3.IDPU is connected to its GSE

4. Testing steps:

4.1. verify IDPU to RAS harness by loading simulators

4.1.1. power up s/c and IDPU Instrument power services

4.1.2. verify that IDPU is responsive

4.1.3. verify no voltage on RAS harness in IDPU SAFE mode (power-up default)

4.1.4. command IDPU to provide power to RAS sequentially and verify voltage levels on harnesses and load simulators

4.1.5. verify that external LED works

4.2. Power off IDPU, mate IDPU to RAS
4.3. Power on IDPU
4.4. verify RAS temperature sensors read appropriate levels
4.5. set temperature stabilization system to some non-ambient value and verify that system works
4.6. actuate RAS shutter. Verify optically by removing baffle cover. Reset the shutter pinpuller and verify optically. Remount baffle cover.
4.7. Power-on RAS and verify performance parameters:
4.7.1. command the internal test pulser with TBD sequence
4.7.2. verify telemetry for the different RAS modes
4.7.3. record full RAS image
4.7.4. dark level image data at given temperature
4.7.5. switch-on external LED and operate RAS in event-mode
4.7.6.
4.7.7.
4.7.8.
4.7.9.

9. Test Objectives:	test functionality and performance (reduced) of RAS after assembly on s/c
10. Success Criteria:	system must meet requirements obtained during autonomous calibration
11. Hardware Requirements:	IDPU, including IDPU VME Chassis and ADP/RAS Power Converter RAS RAS GSE (load simulator, external LED driver) Harnesses (IDPU/RAS, external LED driver harness) S/C bus, including S/C to IDPU harness S/C GSE
12. Software Requirements:	FM software developed to control and analyze RAS
13. Facility Requirements:	220 V AC power, manual access to RAS for resetting pinpuller, space for GSE (2x2 m^2)
14. System Dependencies:	IDPU, S/C bus, S/C GSE, RAS, RAS GSE have been successfully tested on their own
15. Staffing Requirements:	R. Henneck, A. Mchedlishvili
16. Notes/Comments:	
17. Failure Implications:	emergency. Delay for repair, may be significant if RAS has to be dismounted, because then also the RAS alignment has to be redone

SAF + Imager Temperature Functional Test Specification

1. Test Name: **Functional Test SAS + imager temperature control**
2. Ref. Code: Func-SAS
3. Point of Contact: Reinhold Henneck

4. System:... Instrument
5. Subsystem: Imager
6. Test Duration: 4 h

7. Contingency Time: ....
8. Test Description:

5. Starting conditions:

5.1. imager and IDPU are mechanically integrated with spacecraft, SAS dust covers remain mounted

5.2.IDPU is electrically mated to s/c and has completed its interface test

5.3.IDPU is connected to its GSE

6.Testing steps:

6.1. verify IDPU to SAS harness by loading simulators

6.1.1. power up s/c and IDPU Instrument power services

6.1.2. verify that IDPU is responsive

6.1.3. verify no voltage on SAS harness in IDPU SAFE mode (power-up default)

6.1.4. verify no voltage on heater/sensor harness in IDPU SAFE mode (power-up default)

6.1.5. command IDPU to provide power to SAS sequentially and verify voltage levels on harnesses and load simulators

6.1.6. command IDPU to provide power to heater/sensor system sequentially and verify voltage levels on harnesses and load simulators

6.2. Power off IDPU, mate IDPU to SAS and heater/sensors

6.3. Power on IDPU

6.4. verify temperature sensors read appropriate levels

6.5. set temperature stabilization system to some non-ambient temperature and verify that temperature follows

6.6. Power-on SAS and verify performance parameters:

6.6.1. command the internal test pulser with TBD sequence

6.6.2. verify telemetry for the different SAS modes

6.6.3. record full SAS image

6.6.4. dark level image data at given temperature

6.6.5.

6.6.6.

6.6.7.

6.6.8.

9. Test Objectives: test functionality and performance (reduced) of SAS and of the imager temperature control after assembly on s/c

10. Success Criteria: system must meet requirements obtained during autonomous calibration

11. Hardware Requirements: IDPU, including IDPU VME Chassis and ADP/SAS Power Converter and temperature control Power Converter
Full imager with SAS
SAS GSE (load simulators for SAS and heater/sensors)
Harnesses (IDPU/SAS, IDPU/heater/sensors)
S/C bus, including S/C to IDPU harness
S/C GSE

12. Software Requirements: FM software developed to control and analyze SAS and temperature control

13. Facility Requirements: space for GSE (2x2 m^2)

14. System Dependencies: IDPU, S/C bus, S/C GSE, SAS, SAS GSE, heaters/sensors, heaters/sensors GSE have been successfully tested on their own

15. Staffing Requirements: R. Henneck, A. Mchedlishvili

16. Notes/Comments:

17. Failure Implications: emergency. Delay for repair, may be significant if SAS, heater/sensors have to be dismounted

Integrated Spacecraft Calibration Test Spec

1. **Test Name:** Integrated Spacecraft Calibration

2. **Ref. Code**: SFT_Spec_Cal

3. **Point of Contact:** D. Smith

4. **System:** Instrument

5. **Subsystem:** Spectrometer

6. **Test Duration:** 1 day

7. **Contingency Time:** 1 day

8. **Test Description:**

Starting condition:
1) Spacecraft and instruments are fully integrated
2) Radiator cooling system is functional
3) Actuator and high-voltage enable plugs are installed in IPC
4) IDPU and spacecraft are powered on
5) Detectors have been brought to operating temperature by the cryocooler, CSAs and HV are on, and detectors are operating nominally
6) There is no other activity around the spacecraft

Test steps:
1) Ba-133 and Co-60 sources are moved into pre-planned positions within 2 m of the spacecraft to test the transmission of various components (spacecraft deck, IDPU boxes, struts, etc.) Spectra are accumulated through telemetry for each configuration. The exact positions are TBD.
2) All positions are repeated to test reproducibility.
3) A quick check is made for consistency between runs and rough consistency with predictions (prepared in advance).
4) Data are stored for future use.

9. **Test Objectives:**

Verify and/or correct Monte Carlo simulations of absorption and scattering from spacecraft components.

10. **Success Criteria**:

The two data sets taken are roughly consistent and the data are available for use after the test.

Since this is a calibration rather than a test, the actual values recorded are not part of the success criteria, just their availability.

11. **Hardware Requirements:**

1) Spacecraft integrated with IDPU, spectrometer, and imager
2) Instrument GSE, including:
    2.1) Spectrometer radiator cooling system
    2.2) Calibrated 100 uCi Ba-133 and Co-60 sources
    3.3) Source stand, yardstick and level for source placement
3) Spacecraft GSE, including:
    3.1) Spacecraft to GSE harness
    3.2) Power rack
    3.3) SCAT rack
    3.4) ITOS system

12. Software Requirements:

1) Realtime display of instrument housekeeping data (temperatures, voltages, reset rate)
2) Realtime acquisition and display of spectra
3) Saving of spectra for analysis offline

13. Facility Requirements:

14. System Dependencies:

Spacecraft, IDPU, GSE, and spectrometer shall have passed functional tests.

15. Staffing Requirements:

The following people or their delegates are required:
Bob Campbell (detectors)
Test Conductor (ITOS operator)

16. Notes/Comments

17. Failure Implications

Failure to acquire these calibration data increases the uncertainty in the spectroscopic response. Since the only failure mode is not to acquire the data, the worst resulting delay is the need for a repetition of the test.

TMS Test Specification

1. Test Name: **After Shipment TMS Tests**
2. Ref. Code: TMS-US-0
3. Point of Contact: Alex Zehnder
4. System: Instrument
5. Subsystem: Imager
6. Test Duration: 1 day
7. Contingency Time:
8. Test Description: Determine the twist between trays and grid pairs after shipment.

1. Starting conditions:

- Imager unpacked, sitting in the shipment rack TMS stand in place,
- TMS CCD focal plane camera 1.3m (+- 2mm) above the sunny side of grids of front tray
- Remove thermal blanket if mounted after shipment

2. Test steps:

- Align TMS stand holding x-y scanner versus imager using alignment lasers at the front end-ring
- Calibrate x-y scanner to imager coordinate system to +- 2 mm using external Lasers
- Step x-y scanner through 11 TMS positions, i.e. 2 for the trays and 9 for grid pairs 1 – 9 using automated TMS software (Laptop based) .
- Determine twist

9. Test Objectives: Verify stable alignment since last TMS test
10. Success Criteria: Twist <= 10 arc seconds
11. Hardware Requirements: Imager in shipment rack or S/C bus
TMS stand,
TMS Laptop,
LED, and x-y controller
special cables (15 m long)
12. Software Requirements: TMS S/W in Laptop
13. Facility Requirements: L x W x H = 2.5 x 2.5 x 3.7 m^2 place, stable,
No room light (tests at night?)
100W AC power 220V,
small lamp and torch light
table
14. System Dependencies: Alignment has to be checked before integration of imager in S/C
Twist has to be compared with previous tests
15. Staffing Requirements: Alex Zehnder

16. Notes/Comments:	Whenever any operation above grids is required, then protection cover for grid tray must be installed.
17. Failure Implications:	emergency, significant delay for repair or realignment.

GDS L&EO Simulation Test Spect

1. Test Name: GDS L&EO Simulation

2. Ref. Code: CPT_GDS

3. Point of Contact: Tim Quinn/UCB

4. System: Ground Station, Backup Ground Stations, SCAT, MOC, SOC

5. Subsystem: ITOS, SOC Real-time System

6. Test Duration: 10 Hours

7. Contingency Time: 2hours

8. Test Description:
This test will simulate the launch and early orbit activities from launch through the first N orbits

9. Test Objectives:
Test voice and data operations, data flows through entire system, system performance, on-orbit procedures and activities.

10. Success Criteria:
Nominal GDS operation and successful completion of L&EO activities.

11. Hardware Requirements:
Spacecraft-to-SCAT-to-MOC interface/network connections. Dynamic orbit simulator.

12. Software Requirements:
Software associated with hardware requirements.

13. Facility Requirements:
N/A

14. System Dependencies:
N/A

15. Staffing Requirements:
Test conductor operating TCW, launch day personnel (Flight Operations Team, instrument personnel, Spectrum Astro personnel).

16. Notes/Comments

GDS Normal Ops Simulation Test Spec

1. Test Name: GDS Normal Operations Simulation

2. Ref. Code: I&T-GDS-Sim

3. Point of Contact: Tim Quinn, UCB

4. System: Berkeley Ground Station, MOC, SOC

5. Subsystem: All MOC systems, all SOC systems

6. Test Duration: 8 hours

7. Contingency Time: 2 hours

8. Test Description:
This test will simulate a normal operations day for HESSI.

9. Test Objectives:
Confirm autonomous functioning of GDS for all routine telemetry and command operations.

10. Success Criteria:
Nominal performance of all systems and procedures.

11. Hardware Requirements:
Spacecraft-to-SCAT-to-MOC interface/network connections, dynamic orbit simulator.

12. Software Requirements:
Software associated with hardware requirements.

13. Facility Requirements:
N/A

14. System Dependencies:
N/A

15. Staffing Requirements:
Test conductor, normal FOT staffing.

16. Notes/Comments

GDS Anomaly Simulation Test Specification

1. Test Name: GDS Anomaly Simulation

2. Ref. Code: CPT_GDS

3. Point of Contact: Tim Quinn/UCB

4. System: Berkeley Ground Station, MOC, SOC

5. Subsystem: All MOC systems, all SOC systems

6. Test Duration: 4

7. Contingency Time: 2

8. Test Description:
Introduce anomalous spacecraft and GDS conditions and test system and FOT response.

9. Test Objectives:
Test GDS and FOT anomaly response.

10. Success Criteria:
Nominal operation of GDS and FOT.

11. Hardware Requirements:
Spacecraft-to-SCAT-to-MOC interface/network connections, dynamic orbit simulator.

12. Software Requirements:
Software associated with hardware requirements.

13. Facility Requirements:
N/A

14. System Dependencies:
N/A

15. Staffing Requirements:
Test conductor, normal FOT staffing.

16. Notes/Comments

Test Support Plan

Test Support at Spectrum Astro

SSL shall support the following tests at Spectrum Astro (ref. Spacecraft Bus Master Program Schedule):

Instrument I/F Test
Install S/A Wings, IAD, First Motion, Remove S/A Wings
Functional Test

Test Support At Berkeley

TBS

Test Support at Environmental Testing

TBS

Test Support at VAFB

TBS

Shipment of GSE from VAFB to KSC on the OSC OCA

OSC specifies the following constraints for shipping GSE on the OCA:

The OCA can carry a maximum of 1500 lbs. of customer racks. Each rack must be carried on to the airplane, therefore the weight of each rack should not exceed 300 – 400 lbs. The racks will be side loaded so the equipment must be able to be transported as such.

Test Support at KSC

Procedures

HESSI Launch Site Procedures			
Test	**Procedure #**	**VAFB 836**	**VAFB 15**
Spacecraft Off-Load from Truck Procedure			
Lifting Procedures			
Unpack Spacecraft and GSE Procedures			
Setup GSE Racks Procedures			
Install Solar Arrays Procedures			
Setup Solar Array First Motion GSE Procedures			
Solar Array First Motion Test Procedure			
Solar Array Illumination setup Procedure			
Solar Array Illumination Test Procedurre			
Spacecraft Functional Test Procedure			
Battery Conditioning Procedure			
Cryostat Vacuum Pump Procedures			
Cryostat Leak Check Procedure			
TMS Setup Procedure			
TMS Test Procedure			
Spacecraft Mate to Tipover Machine Procedure			
Spacecraft Tipover Procedure			
Spacecraft Mate to Byrd-Mobile Procedure			
Spacecraft Mate to Launch Vehicle Procedure			
Spacecraft de-Mate from Byrd Mobile Procedure			