HESSI PROTOFLIGHT SPACECRAFT VIBRATION TEST PLAN

November of 2000

THIS DOCUMENT CONTAINS HAZARDOUS OPERATIONS

HSI_MIT_020D

SIGNATURE PAGE

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1.0 INTRODUCTION

The Vibration tests specified in this plan are performed in order to qualify the High Energy Solar Spectroscopic Imager (HESSI) Spacecraft for launch in accordance with the HESSI-Pegasus Interface Control Document (HESSI Doc # HSI_SYS_030C, OSC Doc # A70370x7rev-). This is a Pegasus XL air launched Small Explorers (SMEX) class mission.

The required vibration test is a Random Excitation Test which will be performed while using Force Limiting. A low level Sine Survey will be performed before and after the Random Vibration Test. This set of tests will be performed in each of the three axes. The sine sweep data will be used to verify the Force Limiting spectra prior to the start of random vibration tests. The low level, so-called pre-, and post-, Sine Sweeps are used to validate the spacecraft structural model, and as a “signature diagnostic” that may provide evidence of possible damage incurred in testing. Low level random pre-tests will be used to “equalize” the random vibration controller inputs. Excessive time dwells in the equalizing process should be avoided, because this is flight hardware. In a separate test, the spacecraft will be suspended from a crane for the Test Payload Attach Fitting (TPAF) pyrotechnic shock test

Tests will be performed with the HESSI proto-flight spacecraft in its flight configuration. Most, but not all, of the MLI thermal blankets will be installed for this test. Variations from the flight configuration will be noted in a test log prior to the start of tests. The spacecraft will be mounted on its “Red Ring”, which in turn mounts to the Vibration Fixture. The 24 Kistler tri-axial force sensors will be positioned between the “Red Ring” and the vibration fixture. The OSC-TPAF will not be used for HESSI vibration testing.

2.0 HESSI and JPL ORGANIZATIONS

Table 1a UCB Cognizant Personnel

Name	***Title***	***Telephone***	***Cell Phone***
Peter Harvey	Project Manager	(510)642-0643	(510)708-7501
Dave Curtis	System Engineer	(510)642-5998	(510)708-7502
David Pankow	Lead Mechanical Engr.	(510)642-1034	(510)708-7503
Bob Pratt	Mechanical/Structural Engr.	(510)643-9652	(510)710-5894
Paul Turin	Mechanical Engr.	(510)642-5280	(510)710-5895
Rick Sterling	Mission I&T	(510)642-6149	(510)708-7505
Ron Jackson	Quality Assurance	(510)643-2625	

Table 1b SAI Cognizant Personnel

Name	***Title***	***Telephone***
Rick Wanner	Project Manager	(480)892-8200
John Jordan	System Engineer	(480)892-8200
Greg Konicke	Structural Dynamics	(480)892-8200
Randy Niemann	Structural Dynamics	(480)892-8200
Jeff Jackson	Electrical Engr.	(480)892-8200

Jeff Squires	Quality Assurance	(480)892-8200

Table 1c JPL Cognizant Personnel

Name	***Title***	***Telephone***
Terry Fischer	Test Lab Manager	(818)354-6220
Dave Boatman	Test Coordinator	(818)354-7643
Doug Perry	Instrumentation Engr.	(818)354-2028
Tony Zavala	Instrumentation Engr.	(818)354-2771
Lee Albers	Test Operations Engr.	(818)393-5816
Tim Werner	Test Operations Engr.	(818)393-1502
Patrick Collins	Test Operations Engr.	(818)354-2011
Dennis Ross	Systems Safety	(818)354-6370
John Vassbinder	Quality Assurance	(818)354-7225
Al Kuchler	Quality Assurance	(818)354-1323

3.0 PROTOFLIGHT & TEST HARDWARE

The major hardware required to perform the test and their weights are listed in the Appendix A1.

4.0 INSTRUMENTATION

Three different types of instrumentation are used in the testing of the HESSI Spacecraft. They are 9251 KISTLER force gages, single axis, and tri-axial accelerometers (all provided by JPL).

The 24 tri-axial force gages are located in a circular pattern spaced equally at 15 degree angles and held between the “Red Ring” and the vibration fixture, or adapter plate. The force gages are preloaded between the “Red Ring” and the Vibration Fixture by ¼-28 x 1.5” grade 8 Socket Head Cap Screws. Torque Screws to **150 in lb (12.5 ft-lb).** Each Force Gage output is connected to a summing box which provides outputs of the total force in each axis direction.

There are 42 (+ control) available data channels for single, or three axis accelerometers that will be located on the spacecraft for data collection and # control accelerometers on the test fixture. The accelerometers that are located on the HESSI spacecraft are listed in the Appendix.

5.0 TEST SPECIFICATIONS

5.1 Low Level Signature Sine Sweep

The **0.25g open force loop** sine sweep from **10 - 2000 Hertz at 4 octaves/minute** is needed to obtain the fundamental modal response of the structure over the specified frequency range.

5.2 Random Vibration

There are three types of random vibration tests: Low level, Intermediate level, and Full level. The Low level random is performed at -18 dB below the full level acceleration spectra. The driving point "apparent mass" will be evaluated, so that the force spectra may be verified, or updated. The intermediate random vibration tests are performed at -12 dB, in dual control mode using the updated force spectra. Time spent in these survey levels should as brief as is practical

Qualification (full) level random tests are performed in dual control mode using the force limiting spectra determined from previous runs. The input levels will be stepped incrementally, using brief equalization stops. The JPL and HESSI Test Engineers will jointly monitor (in real time) the control spectra (acceleration and force, if available) and will be responsible for the decision to stop the test at any point, or to proceed to higher levels. The spacecraft is to be vibrated +3 dB over the Orbital Sciences Corp. HESSI-ICD values, (for protoflight qualification) for 75 seconds duration for all directions. Graphs of these FSD and ASD values are shown in the Appendix.

5.3 Pyrotechnic Shock Separation Test

WARNING

THE FOLLOWING SEQUENCES ARE HAZARDOUS DUE TO FIRING OF SMALL EXPLOSIVES.

- Perform a safety walk down of the test control area.
- Clear the controlled test area of all personnel.

The spacecraft will be suspended from a crane for this test. The Berkeley Lifting Fixture (with its three attachment points at the Imager Center, and the Upper Titanium Rings) will be used for this test.. The spacecraft "Red Ring" will be removed, so that the Orbital TPAF may then be bolted to the spacecraft. While the spacecraft is suspended above the floor, activate the data recorders for the accelerometers with a check mark in the pyro test column of Table # and fire the pyros. ⚠ Pyro firing is performed per Orbital Procedure TBS. Once the pyrotechnics are fired the Orbital TPAF will be allowed to drop onto foam pads placed on the floor.

6.0 TEST RUN SUMMARY

Table 3: Test Run Summary

Test #	Axis	Test	Specifications
1X	X	Pre-Sine Sweep	0.25G, 10 - 2000 Hz, 4 octave/min
2X	X	-18 dB Random	OPEN LOOP, see Figure and Table A1
3X	X	-12 dB Random	DUAL CONTROL, see Figures and Tables A1 & A2 *Go Ahead decision point for HESSI/JPL Test Engineers*

Test #	Axis	Test	Specifications
4X	X	Full Level Random	DUAL CONTROL, see Figures and Tables A1 & A2
5X	X	Post-Sine Sweep	0.25G, 10 - 2000 Hz, 4 octave/min
5X	X	Post-Sine Sweep	0.25G, 10 – 2000 Hz, 4 octave/min
1Y	Y	Pre-Sine Sweep	0.25G, 10 - 2000 Hz, 4 octave/min
2Y	Y	-18 dB Random	OPEN LOOP, see Figure and Table A1
3Y	Y	-12 dB Random	DUAL CONTROL, see Figures and Tables A1 & A2 *Go Ahead decision point for HESSI/JPL Test Engineers*
4Y	Y	Full Level Random	DUAL CONTROL, see Figures and Tables A1 & A2
5Y	Y	Post-Sine Sweep	0.25G, 10 – 2000 Hz, 4 octave/min
1Z	Z	Pre-Sine Sweep	0.25G, 10 - 2000 Hz, 4 octave/min
2Z	Z	-18 dB Random	OPEN LOOP, see Figure and Table A1
3Z	Z	-12 dB Random	DUAL CONTROL, see Figures and Tables A1 & A2 *Go Ahead decision point for HESSI/JPL Test Engineers*
4Z	Z	Full Level Random	DUAL CONTROL, see Figures and Tables A1 & A2
5Z	Z	Post-Sine Sweep	0.25G, 10 – 2000 Hz, 4 octave/min
1P	--	Pyrotechnic Shock	

7.0 DATA PROCESSING

In order to expedite the processing of data between sine sweeps, random vibration, and sine burst tests, all of the sensors should be plotted, as time permits.

Post-test activities will include the generation of Reduced ASCII files containing the data from all, or from selected sensors from each test.

7.1 Initial Sine Sweep Test in Each Axis

7.1.1 During Test

7.1.1.1 Monitor Accelerometer output vs. frequency.
7.1.1.2 Plots of total force magnitude vs. frequency.
7.1.1.3 Plots of driving point apparent mass vs. frequency.

7.1.2 Post Test

7.1.2.1 Reduced ASCII data files containing total force magnitude versus frequency
7.1.2.2 Reduced ASCII data files containing acceleration versus frequency.
7.1.2.3 Reduced ASCII data files containing apparent mass versus frequency.

7.2 Subsequent Sine Sweep Tests

7.2.1 During Tests

7.2.1.1 Plots of Monitor accelerometer outputs vs. frequency.
7.2.1.2 Plots of individual and total force magnitude.

7.3 Low and Intermediate Level Random Vibration Tests

7.3.1 During Tests

7.3.1.1 Plots of acceleration spectral densities (ASD) versus frequency.
7.3.1.2 Plots of total force spectral density (FSD versus frequency.
7.3.1.3 Plots of the driving point apparent mass versus frequency.

7.4 Full Level Random Vibration Tests

7.4.1 During Tests

7.4.1.1 Plots of acceleration spectral density (ASD) versus frequency.
7.4.1.2 Plots of total force spectral density (FSD) versus frequency.
7.4.1.3 Plots of driving point apparent mass versus frequency.

7.4.2 Post Test

7.5.1.1 Reduced ASCII data files of the Force Spectral Density (FSD) vs. frequency.
7.5.1.1 Reduced ASCII data files of accelerometer data (ASD) vs. frequency.

7.5 Pyrotechnic Shock Separation Test

7.5.1 Post Test

7.5.1.1 Reduced ASCII data files of the Force Spectral Density (FSD) vs. frequency.

7.6 Test Comments

All sine sweeps will be conducted using extremal control strategy, with control accelerometer(s) feedback, but FRF response data should be referenced to only one of the input monitors.

Low level random vibration tests will be conducted using extremal control strategy, with control accelerometer(s) feedback, but response data should be referenced to one of the input monitors

Intermediate and full level random vibration tests will be conducted using extremal control strategy with the control accelerometer and force gage spectra feedback.

Force limiting spectra for each axis of the intermediate and full level random vibration tests should be reviewed and updated (if needed) prior to the start of respective tests.

8.0 SAFETY

Personnel shall conform to all applicable safety rules. The salient rules are summarized here.

- Hard hats are worn during all crane operations while in the local area.
- Minimize personnel in the vicinity of live pyrotechnic devices.
- No personnel in test cell while pyrotechnic devices are armed and about to be fired, until pyro activator signals "all clear".
- Suspended loads must be redundantly supported (e.g. qualified & proof tested "saw horses") if personnel must work directly under them (i.e. while mating the Orbital TPAF in preparation for the pyrotechnic shock test).

9.0 HANDLING

To facilitate handling, the complete Protoflight spacecraft test setup may be lifted as a unit using the UCB HESSI spacecraft lifting fixture. This lifting fixture attaches to the Imager Center Ring at three equally spaced locations, and is guided by three brackets attached to the Imager Upper Ring. The load monitoring Hydraset is required for all crane lifting operations. Clean Room, or protective gloves, and ESD straps are required for all spacecraft handling.

10.0 SUCCESS CRITERIA

The HESSI Spacecraft will be considered successfully qualified after it has been exposed to Protoflight Test Levels (force limited random vibration environments) in all 3 Axes, there is no evidence of structural or functional failures from:

a) Visual Inspection
b) Pre- and Post-Sine Sweep signature comparison (expect nearly identical signatures).
c) Between Axis Aliveness Test
d) Comprehensive Performance Test (After Final Test)

11.0 APPROVALS

Following Completion of X-Axis Vibration Test

Criteria	Title	Name	Signature
Visual Inspection	Mechanical Engr.	Paul Turin	
	Quality Assurance	Ron Jackson	
Sine Signature Comparison	Mechanical/Structural Engr.	Bob Pratt	
Between Axis Aliveness Test	Systems Engineer	Dave Curtis	

Following Completion of Y-Axis Vibration Test

Criteria	Title	Name	Signature
Visual Inspection	Mechanical Engr.	Paul Turin	
	Quality Assurance	Ron Jackson	
Sine Signature Comparison	Mechanical/Structural Engr.	Bob Pratt	
Between Axis Aliveness Test	Systems Engineer	Dave Curtis	

Following Completion of Z-Axis Vibration Test

Criteria	Title	Name	Signature
Visual Inspection	Mechanical Engr.	Paul Turin	
	Quality Assurance	Ron Jackson	
Sine Signature Comparison	Mechanical/Structural Engr.	Bob Pratt	
Between Axis Aliveness Test	Systems Engineer	Dave Curtis	
Comprehensive Performance Test	Systems Engineer	Dave Curtis	

HESSI Vibration Test Plan: Appendix A1 Random Vibration Test Levels
Acceleration (ASD) & Force (FSD) Spectral Density

634.9	(lbs) AS TESTED HESSI SPACECRAFT WEIGHT
48.1	(lbs) INTERFACE OR "RED RING" WEIGHT
683.0	(lbs) TOTAL MOVING "MASS"
	VIBRATION INTERFACE PLATE (below force sensors)

HSI_MIT_020D

Table A1: ASD Magnitude Calculations

	Sqrt Σ areas (Grms) =		**3.73**	Sqrt Σ areas (Grms) =		**3.80**	Sqrt Σ areas (Grms) =		**3.73**
	ASD point	Slope	AREA	ASD point	Slope	AREA	ASD point	Slope	AREA
frequency	(G^2/Hz)	(dB/oct)	increment	(G^2/Hz)	(dB/oct)	increment	(G^2/Hz)	(dB/oct)	increment
(Hz)	**X Axis**			**Y Axis**			**Z Axis**		
20	0.0080	*	*	0.0080	*	*	0.0080	*	*
35	0.0080	0.00	0.12	0.0080	0.00	0.12	0.0080	0.00	0.12
40	0.0080	0.00	0.04	0.0320	31.25	0.09	0.0080	0.00	0.04
55	0.0080	0.00	0.12	0.0320	0.00	0.48	0.0080	0.00	0.12
65	0.0080	0.00	0.08	0.0080	-24.98	0.17	0.0080	0.00	0.08
66	0.0080	0.00	0.01	0.0080	0.00	0.01	0.0080	0.00	0.01
80	0.0080	0.00	0.11	0.0080	0.00	0.11	0.0080	0.00	0.11
94	0.0080	0.00	0.11	0.0080	0.00	0.11	0.0080	0.00	0.11
95	0.0080	0.00	0.01	0.0080	0.00	0.01	0.0080	0.00	0.01
104	0.0080	0.00	0.07	0.0080	0.00	0.07	0.0080	0.00	0.07
105	0.0080	0.00	0.01	0.0080	0.00	0.01	0.0080	0.00	0.01
125	0.0080	0.00	0.16	0.0080	0.00	0.16	0.0080	0.00	0.16
500	0.0080	0.00	3.00	0.0080	0.00	3.00	0.0080	0.00	3.00
800	0.0080	0.00	2.40	0.0080	0.00	2.40	0.0080	0.00	2.40
1500	0.0080	0.00	5.60	0.0080	0.00	5.60	0.0080	0.00	5.60
2000	0.0020	-14.51	2.09	0.0020	-14.51	2.09	0.0020	-14.51	2.09

Figure A1: ACCELERATION SPECTRAL DENSITY

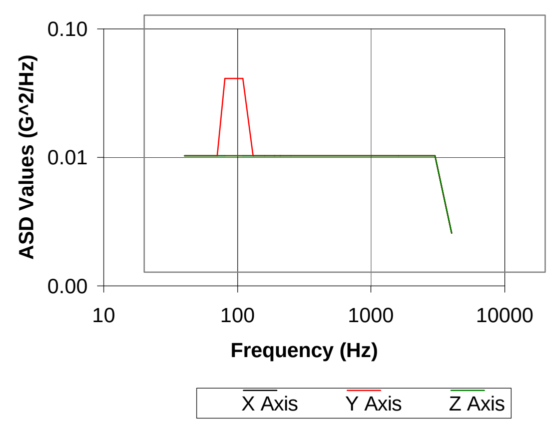
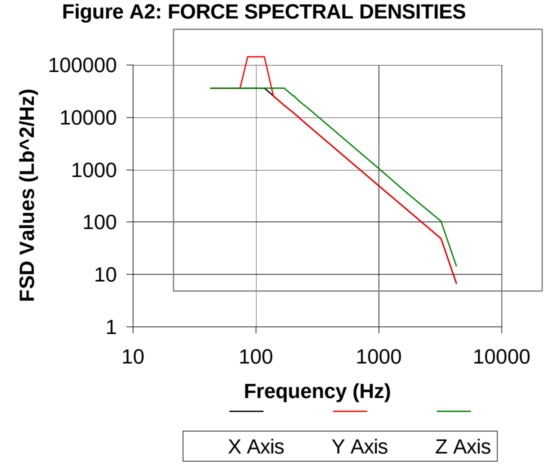


Table A2: FSD Magnitude Calculations

	Sqrt Σ areas (Lbrms) =		**812**	Sqrt Σ areas (Lbrms) =		**1056**	Sqrt Σ areas (Lbrms) =		**1009**
	FSD point	Slope	AREA	FSD point	Slope	AREA	FSD point	Slope	AREA
frequency	(Lb^2/Hz)	(dB/oct)	increment	(Lb^2/Hz)	(dB/oct)	increment	(Lb^2/Hz)	(dB/oct)	increment
(Hz)	**X Axis**			**Y Axis**			**Z Axis**		
20	7464	*	*	7464	*	*	7464	*	*
35	7464	0.00	111964	7464	0.00	111964	7464	0.00	111964
40	7464	0.00	37321	29857	31.25	81976	7464	0.00	37321
55	7464	0.00	111964	29857	0.00	447857	7464	0.00	111964
65	5344	-6.02	63159	5344	-31.00	139245	7464	0.00	74643
66	5184	-6.02	5263	5184	-6.02	5263	7464	0.00	7464
80	3528	-6.02	59870	3528	-6.02	59870	7464	0.00	104500
94	2555	-6.02	42036	2555	-6.02	42036	5406	-6.02	88936
95	2502	-6.02	2528	2502	-6.02	2528	5293	-6.02	5350
104	2088	-6.02	20568	2088	-6.02	20568	4417	-6.02	43516
105	2048	-6.02	2068	2048	-6.02	2068	4333	-6.02	4375
125	1445	-6.02	34407	1445	-6.02	34407	3057	-6.02	72794
500	90	-6.02	135477	90	-6.02	135477	191	-6.02	286628
800	35	-6.02	16935	35	-6.02	16935	75	-6.02	35829
1500	10	-6.02	13171	10	-6.02	13171	21	-6.02	27867
2000	1	-20.53	2102	1	-20.53	2102	3	-20.53	4447

NOTE: The boxes Identify the initial FSD Corner Frequencies

Figure A2: FORCE SPECTRAL DENSITIES



HESSI Vibration Test Plan: Appendix A2 - JPL Accelerometer List and Signal Conditioning

Table A3: JPL Accelerometer List HSI_MIT_020D

	Recorded Data - Time History							Real-Time Data - Freq. Domain		
No.	**RecM5, X**	**RecM5, Y**	**RecM5, Z**	**RecM11, X**	**RecM11, Y**	**RecM11, Z**	**Description**	**M+P, X**	**M+P, Y**	**M+P, Z**
1	1	1	1				Spacecraft Base Ring 1, 1X	7	7	7
2	2	2	2				Spacecraft Base Ring 1, 1Y	8	8	8
3	3	3	3				Spacecraft Base Ring 1, 1Z	9	9	9
4				12			Spacecraft Base Ring 2, 2X	41		
5					12		Spacecraft Base Ring 2, 2Y		41	
6						12	Spacecraft Base Ring 2, 2Z			41
7				13			Spacecraft Base Ring 3, 3X	42		
8					13		Spacecraft Base Ring 3, 3Y		42	
9						13	Spacecraft Base Ring 3, 3Z			42
10	4	4	4				Cryostat Inboard Attach 1, 4X	10	10	10
11	5	5	5				Cryostat Inboard Attach 1, 4Y	11	11	11
12	6	6	6				Cryostat Inboard Attach 1, 4Z	12	12	12
13				14			Cryostat Inboard Attach 2, 5X	43		
14					14		Cryostat Inboard Attach 2, 5Y		43	
15						14	Cryostat Inboard Attach 2, 5Z			43
16				15			Cryostat Inboard Attach 3, 6X	44		
17					15		Cryostat Inboard Attach 3, 6Y		44	
18						15	Cryostat Inboard Attach 3, 6Z			44
19	7	7	7				Imager Mount 1, 7X	13	13	13
20	8	8	8				Imager Mount 1, 7Y	14	14	14
21	9	9	9				Imager Mount 1, 7Z	15	15	15
22				16	25	23	Imager Mount 2, 8X	45		
23				25	16	24	Imager Mount 2, 8Y		45	
24						16	Imager Mount 2, 8Z			45
25				17	26	25	Imager Mount 3, 9X	46		
26				26	17	26	Imager Mount 3, 9Y		46	
27						17	Imager Mount 3, 9Z			46
28	10	10	10				Imager Top Ring, 10X	16	16	16
29	11	11	11				Imager Top Ring, 10Y	17	17	17
30	12	12	12				Imager Bottom Ring, 11X	18	18	18
31	13	13	13				Imager Bottom Ring, 11Y	19	19	19
32	14	14	14				Fine Sun Sensor, 12X	20	20	20
33	15	15	15				Fine Sun Sensor, 12Y	21	21	21
34	16	16	16				Fine Sun Sensor, 12Z	22	22	22
35	17	17	17				Magnetometer, 13X	23	23	23
36	18	18	18				Magnetometer, 13Y	24	24	24
37	19	19	19				Magnetometer, 13Z	25	25	25
38	20	20	20				Deck, Box Foot Quad 1, 14X	26	26	26
39	21	21	21				Deck, Box Foot Quad 1, 14Y	27	27	27
40	22	22	22				Deck, Box Foot Quad 1, 14Z	28	28	28
41							Deck, Box Foot Quad 2, 15X			
42							Deck, Box Foot Quad 2, 15Y			
43				1	1	1	Deck, Box Foot Quad 2, 15Z	29	29	29
44							Deck, Box Foot Quad 3, 16X			
45							Deck, Box Foot Quad 3, 16Y			
46				2	2	2	Deck, Box Foot Quad 3, 16Z	30	30	30
47				18	24	29	Deck, Box Foot Quad 4, 17X	47		
48				24	18		Deck, Box Foot Quad 4, 17Y		47	
49				3	3	3	Deck, Box Foot Quad 4, 17Z	31	31	31
50	23	23	23				SSR, Inboard (negR), 18R	32	32	32
51				4	4	4	SEM, Outboard, 19R	33	33	33
52				5	5	5	Particle Detector, 20X	34	34	34
53				6	6	6	Particle Detector, 20Y	35	35	35
54				7	7	7	Particle Detector, 20Z	36	36	36
55				8	8	8	SA Wing X Upper TiNi, 21X	37	37	37
56				27		18	SA Wing X Upper TiNi, 21Z			47
57				9	9	9	SA Wing X Lower TiNi, 22X	38	38	38
58				28		20	SA Wing X Lower TiNi, 22Z			
59				20	20		SA Wing X Lower Rt. Inside, 23X			
60				21			SA Wing X Top Rt. Inside, 24X			
61				10	10	10	SA Wing Y Upper TiNi, 25Y	39	39	39
62					27	27	SA Wing X Upper TiNi, 25Z			
63				11	11	11	SA Wing Y Lower TiNi, 26Y	40	40	40
64					28	28	SA Wing X Lower TiNi, 26Z			
65				29	29		SA Wing Y Lower Left Inside, 27Y			
66					21		SA Wing Y Top Left Inside, 28Y			
67				22			SA Wing X Top Rt. Outside, 29X			
68					22		SA Wing Y Top Left Outside, 30Y			
69				19	23	21	Roll Angle Sensor, 31X	48		
70				23	19	22	Roll Angle Sensor, 31Y		48	
71						19	Roll Angle Sensor, 31Z			48
	24	24	24				Force Sum, X	4	4	4
	25	25	25				Force Sum, Y	5	5	5
	26	26	26				Force Sum, Z	6	6	6
	27	27	27				Control Accel 1	1	1	1
				30	30	30	Control Accel 2	2	2	2
	30	30	30				Monitor Accel			
	28	28	28				Armature Current	3	3	3
	29	29	29				PA input			
	31	31	31	31	31	31	Sine Reference			
	32	32	32	32	32	32	Voice			

HESSI Vibration Test Plan: Appendix A3
Accelerometer Location and Utilization Callout
HSI_MIT_020D
Table A4: UCB Accelerometer List

description	X AXIS TEST	Y AXIS TEST	Z AXIS TEST	X AXIS Ch.I.D.	Y AXIS Ch.I.D.	Z AXIS Ch.I.D.
*$Spacecraft Base Ring 1	1(X,Y,Z)	1(X,Y,Z)	1(X,Y,Z)		(See Table A3)	
*$Spacecraft Base Ring 2	2X	2Y	2Z			
*$Spacecraft Base Ring 3	3X	3Y	3			
*$Cryostat Inboard Attach 1	4(X,Y,Z)	4(X,Y,Z)	4(X,Y,Z)			
*$Cryostat Inboard Attach 2	5X	5Y	5Z			
*$Cryostat Inboard Attach 3	6X	6Y	6Z			
*Imager Mount 1	7(X,Y,Z)	7(X,Y,Z)	7(X,Y,Z)			
*Imager Mount 2	8(X,Y)	8(X,Y)	8(X,Y,Z)			
*Imager Mount 3	9(X,Y)	9(X,Y)	9(X,Y,Z)			
*Imager Top Ring	10(X,Y)	10(X,Y)	10(X,Y)			
*Imager Bottom Ring	11(X,Y)	11(X,Y)	11(X,Y)			
*Fine Sun Sensor	12(X,Y,Z)	12(X,Y,Z)	12(X,Y,Z)			
*Magnetometer	13(X,Y,Z)	13(X,Y,Z)	13(X,Y,Z)			
*#Deck, Box Foot Quad1	14(X,Y,Z)	14(X,Y,Z)	14(X,Y,Z)			
*Deck, Box Foot Quad 2	15Z	15Z	15Z			
*Deck, Box Foot Quad 3	16Z	16Z	16Z			
*Deck, Box Foot Quad 4	17(X,Y,Z)	17(X,Y,Z)	17(X,Z)			
SSR, Inboard (neg R)	18R	18R	18R			
SEM, Outboard (pos R)	19R	19R	19R			
Particle Detector	20(X,Y,Z)	20(X,Y,Z)	20(X,Y,Z)			
SA Wing X Upper TiNi	21(X,Z)	21X	21(X,Z)			
SA Wing X Lower TiNi	22(X,Z)	22X	22(X,Z)			
SA Wing X Lower Rt. Inside	23X	23X				
SA Wing X Mid. Rt. Inside	24X					
SA Wing Y Upper TiNi	25Y	25(Y,Z)	25(Y,Z)			
SA Wing Y Lower TiNi	26Y	26(Y,Z)	26(Y,Z)			
SA Wing Y Lower Left Inside	27Y	27Y				
SA Wing Y Mid. Left Inside		28Y				
SA Wing X Top Rt. Outside	29X					
SA Wing Y Top Left Outside		30Y				
*Ctr. Cyl., near RAS bolts	31(X,Y)	31(X,Y)	31(X,Y,Z)			

Comments & Explanations
Cols. B,C,D Identify the test axis & measuring locations. i.e. (X axis, 1X) means X axis in X test
Cols. E,F,G are intended to represent data channels
Locs. 1, 2 & 3 are Vertical Planes indexed to the Imager Hard Points, CCW starting from from -Y
Quadrants 1, 2, 3 & 4 are CCW starting from from -Y
The "*" Asterisk indicates a tri-axial accelerometer
The “#” denotes location between SEM and IDPU
The "$" identifies accelerometers that will be removed for the TPAF shock tests

Accelerometer List for TPAF Pyrotechnic Shock Test

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Table A5: Accelerometer List for TPAF Pyrotechnic Shock Test

FIRST RECORDER (15 channels @ 80 kHz, or 7 ch. @ 160kHz)

JPL I.D.	HESSI I.D.	SHOCK Accels and Locations	Sampling (kHz)	Radial direction	Tangent direction	Vertical direction
	S1,2,3	TPAF or Base Ring at least 6" from pyro	160	X	X	X
	S4,5	TPAF or Base Ring radially opposite pyro	80	X	X	
	S6	Cryostat Leg closest to pyro, Outboard	80	X		X
	S7	Cryostat Leg opposite pyro, Outboard	80	X		X
	S8, S9	Vert (Z) Torque Rod Mt.	80	X		X

NOTE: TPAF Pyrotechnic Bolt Cutter is HESSI (+X), Pegasus (-Z) ...OSC Fig 5.5

SECOND RECORDER (15 channels @ 80 kHz)

JPL I.D.	HESSI I.D.	Vibration Accels and Locations	Sampling (kHz)	Radial direction	Tangent direction	Vertical direction
	S10,11	Cryostat Inboard Attach closest to Pyro	80	X		X
	S12,13	Cryostat Inboard Attach opposite Pyro	80	X		X
	7Z	Imager Mount 1	80			X
	14Z	Deck, Box Foot Quad1	80			X
	15Z	Deck, Box Foot Quad 2	80			X
	16Z	Deck, Box Foot Quad 3	80			X
	17Z	Deck, Box Foot Quad 4	80			X
	22Z	SA Wing X Lower TiNi	80			X

HESSI Vibration Test Plan: Appendix A5 - FEA Results: Spacecraft Effective Mass Data
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Table A6: Spacecraft Effective Mass vs.Frequency

MODE NR	Frequency (Hz)	Cum. Mx X axis	Cum. My Y axis	Cum. Mz Z axis
1	29.4	0.996	0.996	1.000
2	29.4	0.993	0.993	1.000
3	49.0	0.881	0.717	1.000
4	49.1	0.592	0.607	1.000
5	56.9	0.531	0.544	0.999
6	57.6	0.486	0.498	0.999
7	58.3	0.486	0.498	0.999
8	59.0	0.486	0.498	0.999
9	61.1	0.460	0.470	0.998
10	62.1	0.431	0.450	0.998
11	62.3	0.428	0.449	0.998
12	62.5	0.427	0.447	0.998
13	62.9	0.366	0.390	0.998
14	63.6	0.324	0.364	0.998
15	64.2	0.322	0.335	0.997
16	65.5	0.321	0.334	0.997
17	68.1	0.320	0.334	0.997
18	69.3	0.320	0.333	0.792
19	71.0	0.320	0.332	0.785
20	71.9	0.319	0.331	0.746
21	76.7	0.318	0.331	0.741
22	79.9	0.318	0.330	0.738
23	81.0	0.315	0.322	0.729
24	82.1	0.314	0.319	0.728
25	82.9	0.313	0.319	0.727
26	84.6	0.312	0.319	0.724
27	85.9	0.311	0.318	0.724
28	86.2	0.309	0.317	0.723
29	94.9	0.309	0.317	0.723
30	95.8	0.286	0.316	0.723
31	95.8	0.284	0.265	0.723
32	95.8	0.256	0.264	0.723
33	106.6	0.256	0.264	0.723
34	107.4	0.255	0.262	0.723
35	107.7	0.255	0.262	0.723
36	107.7	0.255	0.262	0.723
37	107.8	0.255	0.259	0.723
38	109.4	0.254	0.258	0.722
39	109.9	0.254	0.258	0.722
40	111.4	0.253	0.257	0.722
41	117.2	0.247	0.253	0.716
42	119.6	0.247	0.253	0.716
43	121.2	0.246	0.253	0.716
44	122.3	0.245	0.252	0.716
45	123.1	0.245	0.252	0.703
46	123.7	0.245	0.252	0.703
47	125.8	0.245	0.251	0.650
48	126.6	0.245	0.251	0.424
49	129.5	0.244	0.251	0.424
50	130.9	0.244	0.251	0.424
51	132.5	0.244	0.251	0.410
52	134.5	0.243	0.250	0.376
53	139.3	0.241	0.249	0.359
54	141.3	0.240	0.248	0.304
55	142.7	0.239	0.239	0.238
56	146.4	0.237	0.239	0.208
57	148.7	0.171	0.204	0.208
58	148.9	0.126	0.142	0.208
59	149.6	0.124	0.128	0.207
60	150.8	0.124	0.128	0.206

Figure A3: Spacecraft Effective Mass vs Frequency (6 DOF Fixed @ Base Ring)