STEREO IMPACT

Suprathermal Ion Telescope (SIT)

Acoustics and Vibration Test Plan

Baseline

17 January 2004

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Steve Wasserzug Date

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Lillian Reichenthal Date

Vibration test
As-run procedure
10 May 05
to
12 May 05

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1 Introduction

1.1 Scope

This plan describes the STEREO IMPACT Suprathermal Ion Telescope (SIT) dynamic tests in accordance with STEREO environmental test requirements. The plan includes test configurations, levels, tolerances, facilities, instrumentation locations, data recording, and data analysis. This plan does not include SIT preparation, handling, or functional testing, which are called out in SIT procedures.

1.2 Applicable Documents

1. 7381-9003, APL, *STEREO Environment Definition, Observatory, Component and Instrument Test Requirements Document*
2. 7381-9012, APL, *STEREO IMPACT Interface Control Document*
3. *STEREO IMPACT Suprathermal Ion Telescope (SIT) Acoustics and Vibration Functional Test*

1.3 Requirements Verification

Successfully completing these tests will verify three requirements for each SIT FM. Refer to the *IMPACT Verification Matrix* for the requirements listed below.

Requirement Number	Requirement Description	Source(s)
3.6	Instrument Sine Vibration Tests	7381-9003, Sec 3.4.2.1 7381-9012, Sec 6.1.3.2
3.7	Random Vibration for Instruments	7381-9003, Sec 3.4.2.2 7381-9012, Sec 6.1.3.2
3.8	Instrument Acoustic Test	7381-9003, Sec 3.4.3 7381-9012, Sec 6.1.3.2

2 Test Approach and Requirements

2.1 Sine Survey

SIT will undergo protoflight vibration testing in three axes. A 0.25 g sine survey shall precede and follow each vibration run in each axis. See Table 1.

Table 1: SIT Sine Survey Spec

Frequency, Hz	Survey Level
5-2000	0.25 g

Sweep Rate: 4 octave/minute

2.2 Random Vibration

Table 2 [1] shows the protoflight level random vibration specs. Test runs at –15 dB and –12 dB shall precede each random vibration run. The force specs will also be scaled for the –12 dB run. Test runs at –9 dB or –6 dB may be added or deleted if deemed necessary by the test director to verify the test input. The full-level random vibration test run can proceed directly from the lower-level runs without stopping; each full-level run will be followed by a 0.25 g sine survey.

Table 2: SIT Protoflight Random Vibration Spec

Axis	Frequency, Hz	Protoflight Level
Perpendicular to Mounting Panel	20	0.0063 g^2/Hz
	20 – 80	+ 6 dB/octave
	80 – 800	0.1 g^2/Hz
	800 – 2000	- 9 dB/octave
	2000	0.0065 g^2/Hz
	Overall	10.4 g_{rms}
Parallel to Mounting Panel	20	0.0031 g^2/Hz
	20 – 80	+ 6 dB/octave
	80 – 800	0.05 g^2/Hz
	800 – 2000	- 9 dB/octave
	2000	0.0032 g^2/Hz
	Overall	7.4 g_{rms}

Duration: 1 minute per axis, 3 orthogonal axes

2.3 Sine Vibe

Table 3 [1] shows the protoflight level sine spec. A test run at –15 dB shall precede each sine vibration run. Test runs at –12 dB or –9 dB may be added or deleted if deemed necessary by the test director to verify the test input. Each full level test run will be followed by a 0.25 g sine survey.

Table 3: SIT Sine Vibe Spec

Thrust Axis (X)		Lateral Axes (Y, Z)	
Frequency [Hz]	Acceleration (zero to peak)	Frequency [Hz]	Acceleration (zero to peak)
5 to 7.4	0.5 in (double amplitude)	5 to 6.3	0.5 in (double amplitude)
7.4 to 23	1.4 g	6.3 to 19	1.0 g
25 to 27	16 g	21 to 23	12 g
29 to 100	1.4 g	25 to 100	1.0 g

Rate = 4 octaves/min

Above 50 Hz, component responses may be limited to peak input level.

2.4 Acoustics

SIT will be subjected to protoflight level acoustic testing. Acoustics shall be performed to the requirements and tolerances of Table 4. A test run at –9 dB shall precede each full-level run. Intermediate test runs at –6 dB and –3 dB may be added or deleted if deemed necessary by the test director. The full-level acoustic test run can proceed directly from the lower-level runs without stopping.

Table 4: SIT Acoustic Spec

1/3 Octave Center Frequency [Hz]	Level (ref: 20μPa) [dB]	Tolerance [dB]		1/3 Octave Center Frequency [Hz]	Level (ref: 20μPa) [dB]	Tolerance [dB]
31.5	122.5	as close as possible		630	125	+4, -2
40	125.5	as close as possible		800	123	+4, -2
50	129.5	+4, -2		1000	121	+4, -2
63	131	+4, -2		1250	120	+4, -2
80	133	+4, -2		1600	119.5	+4, -2
100	133	+4, -2		2000	119	+4, -2
125	133	+4, -2		2500	118	as close as possible
160	133.5	+4, -2		3150	116.5	as close as possible
200	134.5	+4, -2		4000	114	as close as possible
250	135.5	+4, -2		5000	110	as close as possible
315	134.5	+4, -2		6300	106	as close as possible
400	131	+4, -2		8000	103	as close as possible
500	128	+4, -2		10000	101	as close as possible

Overall level: 143.6 dB (+3/-1)
Duration: one minute

3 Test Responsibilities

University of Maryland and Goddard Code 660 will provide SIT for dynamic tests in a flight-like configuration. Code 660 will also provide fasteners to bolt SIT to the vibration plate.

Code 660 will provide a cognizant engineer, who will have overall responsibility for SIT, including set up, GSE, and handling.

Name of cognizant engineer: GLENN MASON / KRISTEN NOETMAN

Code 549 will provide a test director who will be responsible for safe and timely execution of the dynamic tests to the requirements specified herein. The test director will examine all dynamic test data immediately following each test run and, with concurrence of the cognizant engineer, will give the go ahead for successive test runs and test tear down at the end of each vibration test axis. The test director will produce a test report within three weeks after testing.

Name of test director: Michelle Gibson / Dan Worth / KC Shah

Code 549 will also provide test operators to perform tests as described in this test plan. The branch will also provide technicians to install accelerometers and force gauges for vibration testing. Accelerometers will be cleaned and applied just prior to vibration testing; this activity will be coordinated with Code 660 and should be done after final bagging of the instrument.

Code 549 will provide a vibration plate with hole patterns suitable for mounting a SIT instrument; Section 10 contains a drawing taken from the SIT ICD, which shows the hole pattern.

A Quality Assurance representative shall monitor all test operations involving flight hardware.

4 Pass/ Fail Criteria

SIT will have successfully passed protoflight level vibration and acoustic tests if structural integrity is maintained throughout the test program, as verified by visual inspection and functional testing performed by the cognizant hardware engineer and University of Maryland.

5 Test Configuration and Equipment

5.1 Vibration Tests

For the vibration test, each FM SIT instrument will be assembled on the shaker as shown in Figure 1 of Section 10. Because of limitations with force limiting, the two test articles will be tested serially. The vibration plate shall be drilled for control and monitor accelerometers. Four force transducers will mount between SIT and the vibration plate, one at each bolt location. Instrument mounting bolts shall be pre-loaded to 500±50 lb. The bolts must be re-torqued because the Ultem® spacers at the interface creep. After the pre-load has stabilized, the load cells can be zeroed out. SIT weighs about 1.5 kg.

5.2 Acoustic Test

For acoustic testing, SIT will be suspended upside down at its mounting supports by parachute cords as close as possible to the center of the chamber.

6 Instrumentation and Controls

6.1 Vibration

Accelerometer control will be used for all random and sine vibration tests. Each SIT test article will be instrumented with two tri-axial accelerometers, as described in Table 5 and shown in Figure 1 of Section 10. The accelerometer blocks will be installed on Kapton tape.

Table 5: SIT Response Accelerometer Locations

Accelerometer Designations	Accelerometer Location
1X, 1Y, 1Z	Electronics Enclosure
2X, 2Y, 2Z	Telescope Housing

For vibration tests, a total of four tri-axial force transducers will be installed between the vibration plate and the test article, oriented parallel to the assembly coordinate axes, and torqued to the appropriate value. The in-axis transducer signals will be summed to obtain the total in-axis force for each axis of shake.

The random vibration input will be force limited. In addition to control accelerometer output, the sum of the in-axis forces from the transducers will be a control input. Force spectral limits can be calculated using the formula in Table 6, based on the semi-empirical method. Calculated spectral values are subject to modification based on information gathered during the low-level sine sweep.

DIGI COUNTING SCALE DC-80
NASA M140867
S/N 581929

WEIGHT

FM1 3.6 lbs

FM2 ____

Table 6: Random Vibration Force Limit Spec

Frequency [Hz]	Force Specification
$20 - f_o$ $f_o - 1000$	$4 \bullet W^2 \bullet A$ lb^2/Hz -6 dB/Oct

f_o = first mode of test article
W = test article weight [lb]
A = acceleration spectral density [G^2/Hz]

All control and response data will be recorded for all test runs. The recorder will operate at a speed sufficient to provide a minimum of 2500 Hz upper frequency response for random vibration testing.

6.2 Acoustics

The acoustic test spectrum will be controlled by the average signal from four microphones placed about the test article. Each control-monitor microphone pair should be placed about one to two feet from the nearest test article surface as advised by the test director.

6.3 Test Tolerances

Random vibration tests shall be conducted within the following tolerances:

spectral values:	±3 dB when measured in frequency bandwidths of 25 Hz or less.
wide band (RMS) level:	±1.5 dB
frequency:	±5%
time:	±5%

Acoustic tests shall be conducted within the tolerances of Table 4.

7 Test Sequence

7.1 Vibration

Each of the six tests will be conducted in the sequence shown in the tables below. The six tests can be done in any order. Reference 3 contains a handling procedure. Functional checkouts are performed per Section 6.3 of Reference 3.

SIT FM #1	X-AXIS	Date: 10-May-2005	
#	Steps	Results, comments, and observations	Initials
1	Mount SIT to vibration table as described in Section 5.1 (pre-load of 500±50 lb).	~25 in-lb req'd. Waited 1.5hr, negligible Δ in pre-load	[illegible] 10 May 05
2	Run low-level sine survey, examine response plot, and record fundamental frequency, f_o.	f_o = 329 Hz	[illegible] 10 May 05
3	Verify force spec and adjust as required. Connect 28 V to htr (survival)		[illegible] 10 May 05
4	Run pre-random check out at –15 dB (and at other levels as required).		[illegible] 10 May 05
5	Run full level random vibration.		[illegible] 10 May 05
6	Run low-level sine survey and compare to pre-test survey.		[illegible] 10 May 05

SIT FM #1	X-AXIS	Date: 10 MAY 2005	
#	Steps ~~15~~ -12	Results, comments, and observations	Initials
7	Run pre-sine-vibe checkout at ~~15~~ -12 dB (and at other levels as required).		JDW 10 May 05
8	Run full-level sine vibe.		JDW 10 May 05
9	Run low-level sine survey and compare to pre-test survey.		JDW 10 May 05
10	Perform visual inspection and functional test per Reference 3.	OK	SW 10 May 05

Y ~~Z~~-AXIS

SIT FM #1	~~Y-AXIS~~	Date: 12 MAY 2005	
#	Steps	Results, comments, and observations	Initials
1	Mount SIT to vibration table as described in Section 5.1 (pre-load of 500±50 lb).		SW 12 May 05
2	Run low-level sine survey, examine response plot, and record fundamental frequency, f_o.	f_o = ~270 Hz Small peak; larger peak @ 700 Hz	SW 12 May 05
3	~~Verify force spec and adjust as required.~~ SW 5/12/05 *	Not force limiting this axis. adjusted torque up slightly to 25 in-lb as before	SW 12 May 05
4	Run pre-random check out at ~~15~~ -12 dB (and at other levels as required). also -6dB. SW 5/12/05 **	Decided that we WOULD run with force limits; see below.	SW 12 May 05
5	Run full level random vibration.	OK. Force spec clipped resonances @ 270 & 700 Hz	SW 12 May 05
6	Run low-level sine survey and compare to pre-test survey.	Good match ~~below~~ thru 2nd mode @ 700 Hz, noise shifts above that frequency — see plots	SW 12 May 05
7	~~Run pre-sine-vibe checkout at 15 dB (and at other levels as required).~~ SW 5/12/05 Not req'd	NOT DONE	SW 12 May 05
8	Run full-level sine vibe.	OK	SW 12 May 05
9	Run low-level sine survey and compare to pre-test survey.	Good match thru entire f spectrum	SW 12 May 05
10	Perform visual inspection and functional test per Reference 3.		

** Responses @ ~280 Hz & @ ~700 Hz @ accel 2Y were higher than with FM-2 Y-axis shake. Forces were reading factor of 2 too low; force spec was scaled and used for test. Force spec appeared to function exactly as expected. SW 12 May 05

Z-AXIS (~~Y~~)

SIT FM #1	~~Y~~-AXIS	Date: 11 May 05	
#	Steps	Results, comments, and observations	Initials
1	Mount SIT to vibration table as described in Section 5.1 (pre-load of 500±50 lb).	~~~25 in lb required. Waited 1.5 hr, negligible Δ in pre-load.~~	(SU) 10 May 05
2	Run low-level sine survey, examine response plot, and record fundamental frequency, f_o.	f_o = 280 Hz	JBW 11 May 05
3	Verify force spec and adjust as required. Connect 28V to survival htrs~~bus~~.		JBW 11 May 05
4	Run pre-random check out at ~~–15~~ dB (and at other levels as required). 12		JBW 11 May 05
5	Run full level random vibration.		JBW 11 May 05
6	Run low-level sine survey and compare to pre-test survey.		JBW 11 May 05
7	Run pre-sine-vibe checkout at –~~15~~ dB (and at other levels as required). 12		JBW 11 May 05
8	Run full-level sine vibe.		JBW 11 May 05
9	Run low-level sine survey and compare to pre-test survey.		JBW 11 May 05
10	Perform visual inspection and functional test per Reference 3.		KAW 11 May 05

SIT FM #2	X-AXIS	Date: 10 May 05	
#	Steps	Results, comments, and observations	Initials
1	Mount SIT to vibration table as described in Section 5.1 (pre-load of 500±50 lb).	~~500 lb~~	~~LG~~
2	Run low-level sine survey, examine response plot, and record fundamental frequency, f_o.	f_o = 317.9 Hz	JBW 10 May 05
3	Verify force spec and adjust as required.		JBW 10 May 05
4	Run pre-random check out at –15 dB (and at other levels as required).		JBW 10 May 05
5	Run full level random vibration.		JBW 10 May 05

SIT FM #2 X-AXIS		Date: 10 May 05	
#	Steps	Results, comments, and observations	Initials
6	Run low-level sine survey and compare to pre-test survey.		DAV 10 May 05
~~7~~	~~Run pre-sine-vibe checkout at –15 dB (and at other levels as required).~~ SW 10 May 05		
8	Run full-level sine vibe.		DAV 10 May 05
9	Run low-level sine survey and compare to pre-test survey.	OK!	AR 5/10/05
10	Perform visual inspection and functional test per Reference 3.	OK!	AR 5/11/05

SIT FM #2 Y-AXIS		Date: 12 May 05	
#	Steps	Results, comments, and observations	Initials
1	Mount SIT to vibration table as described in Section 5.1 (pre-load of 500±50 lb).	Connected 28V to survival heaters	SW 12 May 05
2	Run low-level sine survey, examine response plot, and record fundamental frequency, f_o.	f_o = ~270Hz Small peak, larger peak @ ~1270Hz	SW 12 May 05
3	Verify force spec and adjust as required.	Force X-ducer problem; could not troubleshoot; decided to ignore force spec; not much relief	SW 12 May 05
4	Run pre-random check out at ~~–15~~ –12 dB SW 12 May 05 (and at other levels as required).	Small peak near 270Hz (Q<3). Peak out near 1500Hz, low energy. Procede with no force limit.	SW 12 May 05
5	Run full level random vibration.	OK without force limit. "2Y" had ~2X the energy as "2X"	SW 12 May 05
6	Run low-level sine survey and compare to pre-test survey.	Check overlays on screen; good match.	SW 12 May 05
7	Run pre-sine-vibe checkout at ~~–15~~ –12 dB SW 12 May 05 (and at other levels as required).	OK	SW 12 May 05
8	Run full-level sine vibe.	OK	SW 12 May 05
9	Run low-level sine survey and compare to pre-test survey.	Good match.	SW 12 May 05
10	Perform visual inspection and functional test per Reference 3.		SW 12 May 05

model # LL$6040 cal 5/25/04 exp 5/25/05 } LG 5/11/05
LAMBDA NASA # M153134

SIT FM #2	Z-AXIS	Date: 11 May 05	
#	Steps	Results, comments, and observations	Initials
1	Mount SIT to vibration table as described in Section 5.1 (pre-load of 500±50 lb).	28V connected to Survival Heaters LG 5/11/05; 500 lb.	LG 5/11/05
2	Run low-level sine survey, examine response plot, and record fundamental frequency, f_o.	f_o = 282	DDW 5/11/05
3	Verify force spec and adjust as required.		DDW 5/11/05
4	Run pre-random check out at ~~–15~~ 12 dB (and at other levels as required).		DDW 5/11/05
5	Run full level random vibration.		DDW 5/11/05
6	Run low-level sine survey and compare to pre-test survey.		SW 5/11/05
7	~~Run pre-sine-vibe checkout at –15 dB (and at other levels as required).~~ SW	12 May 05	
8	Run full-level sine vibe.		DDW 5/11/05
9	Run low-level sine survey and compare to pre-test survey.		SW 5/12/05
10	Perform visual inspection and functional test per Reference 3.	OK	KW 5/11/05

7.2 Acoustics

Each of the two tests will be conducted in the sequence shown in the tables below. The two tests can be done in either order. Reference 3 contains a handling procedure. Functional checkouts are performed per Section 6.2 of Reference 3.

SIT FM #1		Date:	
#	Steps	Results, comments, and observations	Initials
1	Suspend SIT in the chamber from parachute cord as described in Section 5.2.		
2	Run pre-random check out at –9 dB (and at other levels as required).		
3	Run full level acoustic test.		

SIT FM #1		Date:	
#	Steps	Results, comments, and observations	Initials
4	Perform visual inspection and functional test per Reference 3.		

SIT FM #2		Date:	
#	Steps	Results, comments, and observations	Initials
1	Suspend SIT in the chamber from parachute cord as described in Section 5.2.		
2	Run pre-random check out at –9 dB (and at other levels as required).		
3	Run full level acoustic test.		
4	Perform visual inspection and functional test per Reference 3.		

8 Data Processing

Data reduction will be required for all control data between test runs along with some or all of the response data. All data will be reduced from the full level test runs for inclusion in the test report.

Acceleration and force plots will be generated between test runs to analyze input, response, and data fidelity. All full level data channels will be plotted in the frequency domain with annotation and in a format suitable for inclusion in the final test report.

Low-level sine survey and sine vibration data will be analyzed and plotted in the following formats:

accelerometers g_{pk} vs. frequency
force transducers lb_{pk} vs. frequency

Random vibration data will be analyzed and plotted in the following formats:

accelerometers g^2/Hz vs. frequency (20-2000 Hz)
force transducers lb^2/Hz vs. frequency (20-2000 Hz)

Acoustic data will be analyzed and plotted in the following formats:

accelerometers g^2/Hz vs. frequency
SPL dB vs. frequency.

9 Photographic Documentation

Digital photographs will be taken to show the overall setup with test article fully assembled on the vibration fixture and shaker. Close-up photographs will be taken of the accelerometer installation with sufficient detail to allow later accelerometer location identification.

10 Figures

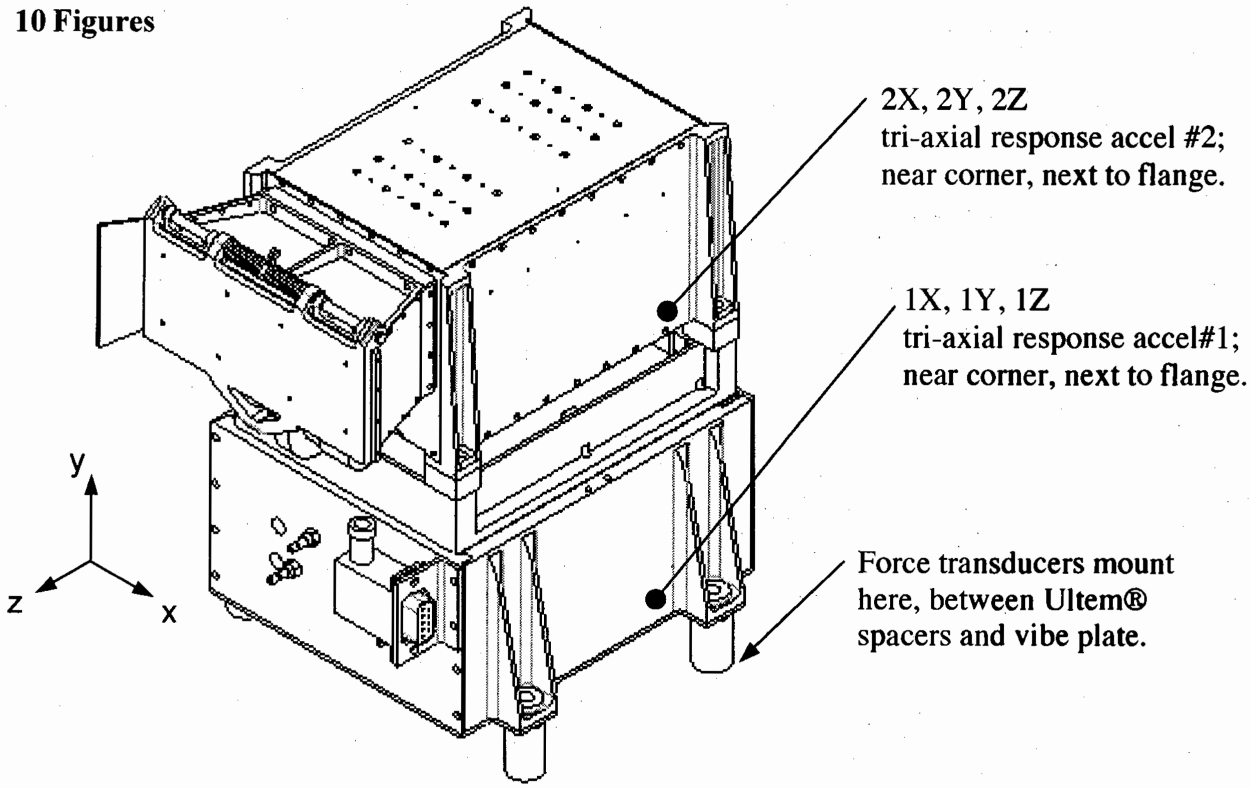

Figure 1: SIT assembly and approximate response accelerometer locations

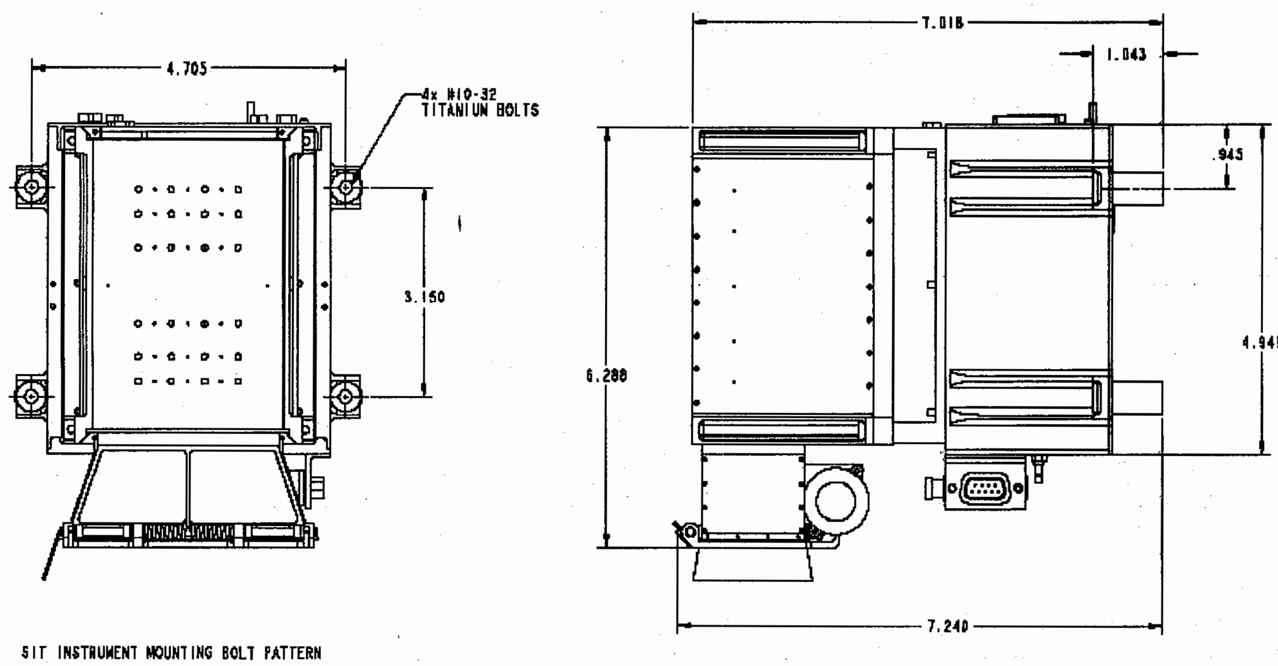

Figure 2: SIT footprint for vibration plate.