Report 11655
13 March 2000

AEROJET

Integrated Advanced Microwave Sounding Unit-A (AMSU-A)

Engineering Test Report

AMSU-A2 METSAT Instrument (S/N 108) Acceptance Level Vibration Tests of Dec 1999/Jan 2000

(S/O 784077, OC-454)

Contract No. NAS 5-32314
CDRL 207

Submitted to:

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Submitted by:

Aerojet
1100 West Hollyvale Street
Azusa, California 91702

Aerojet

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TO: P. K. Patel

FROM: R. J. Heffner

DATE: 13-March-2000
A2vib-sn108.doc
170:8400#2000#281

SUBJECT: AMSU-A2 METSAT Instrument (S/N 108) Acceptance Level Vibration Tests of Dec 1999/Jan 2000 (S/O 784077, OC-454)

COPIES TO: J. L. Cavanaugh, A. Nieto, L. T. Paliwoda, R. H. Platt, D. L. Tran, Writer, File

REFERENCES:

1 "Advanced Microwave Sounding Unit-A2 (AMSU-A2) Instrument Assembly METSAT Acceptance Level Vibration Testing", Shop Order 784077 (OC-454), Dec 1999.
2. "METSAT/AMSU A2 Top Assy", Dwg. 1331200.
3. "Vibration and Sine Burst Qualification and Acceptance Test Procedure for the AMSU-A System", Aerojet Process Specification AE-26151/1E, 28 October 1998.
4. "AMSU-A2 METSAT Instrument (S/N 107) Acceptance Level Vibration Tests of May 1999 (S/O 724647, OC-454)", 170:8411#1999-#310, 24 June 1999.
5. "Failure Review Board (FRB) Meeting Held December 9, 1999 (F/AR 219)", AMSU-A2, S/N 108, Signal Return to Chassis Ground Isolation Lost, IOM 6262/1999#651, E. Lorenz.
6. "Failure Review Board (FRB) Meeting Held December 21, 1999 (F/AR 220)", AMSU-A2, S/N 189, Reflector Translation during Random Vibration, IOM 01/2000#14 Rev A, D. Woon.

PURPOSE

The purpose of this memo is to present a summary of the acceptance level vibration testing performed in Dec 1999 and Jan 2000 on the S/N 108, METSAT, AMSU-A2, Ref. 2 Instrument.

SUMMARY

The Ref. 2, S/N 108, METSAT, AMSU-A2 instrument was vibration tested to acceptance levels per the Ref. 3 procedure and Ref. 1 shop order. The instrument withstood the 5.9 Grms random vibration test, and the 13.1g sine burst test in each of the three orthogonal axes.

X-axis testing (nadir axis, perpendicular to baseplate) was performed first, with pre-random and post-random low-level sine sweep responses showing some resonant frequency

degradation (up to 4 Hz). Sine burst produced no appreciable changes in response throughout the instrument. The frequency changes induced by the random vibration run are minor and acceptable, and are consistent with the instrument going through a "settling-in" phase. A Limited Performance Test (LPT) was successfully performed after the X-axis vibration tests.

Y-axis vibration testing (velocity axis, in line with drive) contained one false start when the chassis ground was lost during random vibration. After reworking the shorted area, instrument testing was begun again and run without incident from the beginning low level sine sweep. Frequency loss was minimal in the random vibration test (as well as the sine burst test, with 0 to 1 Hz frequency degradation seen throughout the structure (including the reflector). After vibration, the LPT was performed, with the instrument passing the test.

Z-axis vibration tests, (sun axis, perpendicular to the drive and parallel to the baseplate) were run without incident, with additional changes in response level and frequency (up to 5 Hz in the reflector). However, the remaining frequency levels were quite comparable to Ref 4 (S/N 107) levels. The sine burst test, again in the Z-axis, produced no response changes. Post-vibration inspection of the instrument, however, indicated that the reflector had translated along its axis nearly 1/10 inch.

The suspect joint was shown to possess lower than expected breakaway torque, suggesting the possibility of an improperly applied preload torque. The new joint incorporated a two step torquing sequence, with a hold period used after tightening to 60 to 65 in-lb, to allow the joint to come to an equilibrium state, and then applying the full 90 to 95 in-lbs

With re-established proper preload, both the X and Z axes test sequences were re-examined. Starting with the more benign X-axis tests, on 11 Jan 2000, the same sine sweep, random, sine sweep, sine burst, sine sweep progression was again utilized in the acceptance level re-test. Results were very similar to the 03 December 1999 X-axis tests, with no more than 1 Hz variation. An LPT was run with the instrument passing the test.

On 12 Jan 2000, the more significant Z-axis tests were re-run, with acceptable results indicating minimal further frequency degradation (4-5 Hz maximum). Remaining natural frequencies, however, are well above the 100 Hz requirement, with 136 Hz recorded in the Z-axis responses. An LPT was run with the instrument passing the test.

Minimum resonant frequency remains above the 100 Hz level requirement (Ref. Paragraph 3.4.3.1 of Appendix E, METSAT Unique Performance Verification Requirements of the Performance Assurance Requirements (PAR, GSFC S-480-79, Attachment D, Rev. A) with the minimum recorded resonant frequency of 109 Hz.

Limited performance tests (LPT's) were successfully run after the first two axes of vibration testing. After the final vibration axis (X) a more thorough sub-comprehensive performance test (sub-CPT) was successfully run. Passing the sub-CPT signified the successful completion of the S/N 108 A2 acceptance vibration testing.

DISCUSSION

METSAT acceptance level testing was begun on the S/N 108 A2 assembly during the month of Dec 1999, starting in the METSAT X-axis (nadir axis, perpendicular to baseplate). The vibration acceptance test sequence, for each axis, per the Ref. 3 procedure was:

1. Low level sine sweep (0.25 g)
2. Acceptance level random vibration (5.9 Grms spec.)
3. Low level sine sweep (0.25g)
4. Acceleration/sine burst (13.1 g)
5. Low level sine sweep (0.25g)

Testing of the 1st test axis, the X-axis, was completed without incident on 03 December 1999. Some change in frequency response, (up to 4 Hz) was experienced throughout the structure. At the reflector, a 1 Hz change was seen. These changes are minor and consistent with the instrument "settling-in". See Table 1 for natural frequencies, calculated Q levels, and predicted 3σ loads. The natural frequencies are compared to Ref. 4, S/N 107 similar quantities. After X-axis random vibration, and the sine burst test (no change in frequency associated with sine burst test), a LPT was performed and was successful.

Y-axis vibration testing (velocity axis, in line with drive) followed on 06 December 1999. After running the initial ¼ g sine sweep, the random vibration test was started. After progressing uneventfully through the lower levels, at full acceptance level the signal return to the chassis ground isolation was lost. Instrument testing was terminated, per Ref. 5. Locating the shorted components (DRO shorted to shelf), repairing the DRO attachment joints, and then reassembling the S/N 108 allowed the Y-axis testing to resume on 16 Dec 1999. The test sequence was begun again with an initial ¼ g sine sweep run again, followed by a new 60 sec. random vibration. Frequency loss was minimal in the random vibration test (as well as the sine burst test, with 0 to 1 Hz frequency degradation seen throughout the structure (including the reflector). See Table 1 for natural frequencies, calculated Q levels, and predicted 3σ loads. The natural frequencies for S/N 107 are presented in Table 1 for comparison purposes. After vibration, the LPT was performed, with the instrument passing the test.

The Z-axis vibration tests, (sun axis, perpendicular to the drive and parallel to the baseplate) were completed without apparent incident on 17 December 1999. Results showed through the pre and post-random sine sweeps that additional changes in response level and frequency (up to 5 Hz in the reflector) were evident. However, the remaining frequency levels were quite comparable to Ref 4 (S/N 107) levels. The sine burst test, again in the Z-axis, produced no response changes. See Table 1 for natural frequencies, calculated Q levels, and predicted 3σ loads. Predicted frequencies for S/N 108 are again quite similar to the S/N 107, X-axis, post-acceptance test results.

Post-vibration inspection of the instrument identified a significant problem, that during the Z-axis tests, the reflector had translated along its axis nearly 1/10 inch. This left the reflector with only a 0.045 inch gap to the compensator panel, while the clearance to the motor panel grew to 0.219 in. By specification, the gaps need to be within 0.030 in of one another. FAR 220 (Ref. 6) was assigned to investigate the anomaly and correct this problem. Ref. 6 was unable to come up with conclusive evidence that could identify a root cause, however, the suspecting problem was thought to be an inadequate hub clamping force. To this end, the hub clamp was replaced and improved torquing procedures were introduced (see Ref. 6) with the replacement hub clamp.

The suspect joint was shown to possess lower than expected breakaway torque, suggesting the possibility of an improperly applied preload torque. The new joint incorporated a two step torquing sequence, with a hold period used after tightening to 60 to 65 in-lb, to allow the joint to come to an equilibrium state, and then applying the full 90 to 95 in-lb.

Per NASA direction, both the X and Z axes test sequences were to be re-examined. Starting with the more benign X-axis tests, on 11 Jan 2000, the same sine sweep, random, sine sweep, sine burst, sine sweep progression was again utilized in the acceptance level re-test. Comparing the Jan 11 X-axis frequency results to the initial Dec 03 X-axis evaluations, in Table 1, show little difference (1 Hz). An LPT was run with the instrument passing the test.

On 12 Jan 2000, the more significant Z-axis tests were re-run. Table 1 frequency comparisons with the initial Z-axis 17 Dec 1999 test results show a small additional frequency degradation throughout the instrument of 4 to 5 Hz. Remaining natural frequencies, however, are well above the 100 Hz requirement, with 136 Hz recorded. An LPT was run with the instrument passing the test.

Sample calculations of the Table 1 predicted loads at full level (-0 dB) random vibration, using Miles' equation with low level sine sweep amplification factors, are shown for Accel#A7Z for Z-axis test data, Z response. For S/N 108,

$$\begin{aligned} \text{Peak } 3\sigma &= 3 \times [\,(\pi/2)(\text{PSD})(f_{ni})(Q)\,]^{1/2} \\ &= (3)\,[\,(\pi/2)\,(0.037)\,(137)\,(40.9)\,]^{1/2} \\ &= 54.3 \text{ g's} \end{aligned}$$

RESULTS

Table 1 displays sine sweep data, for the motor, the structure, and the reflector, for all vibration sequences. In Table 1, for each accelerometer, the 1st applicable natural frequency and transmissibility are listed, along with the PSD level of the random vibration spectrum at f_{n1}, and the peak 3σ load (determined via Miles equation). Refs. 4 frequencies are listed for comparison.

As an appendix to this report, the complete list of acceleration and power spectral density (PSD) plots at all response locations, is included.

CONCLUSIONS and RECOMMENDATIONS

The Ref. 2, S/N 108, METSAT, AMSU-A2 Instrument successfully met the acceptance level vibration requirements of Ref. 3. Minimum resonant frequency remains above the 100 Hz level requirement (Ref. Paragraph 3.4.3.1 of Appendix E, METSAT Unique Performance Verification Requirements of the Performance Assurance Requirements (PAR, GSFC S-480-79, Attachment D, Rev. A) with the minimum recorded resonant frequency of 109 Hz. The hub clamp problems exhibited in the 17 Dec 1999 Z-axis tests were solved and demonstrated by the 12 Jan 2000 re-run Z-axis tests where essentially no reflector translation was exhibited. It is recommended to accept the A2 S/N 108 instrument.

R. J. Heffner

R. J. Heffner
Mechanical Design and Analysis

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Table 1 AMSU -A2 METSAT Acceptance Level Test Data Miles' Equation w/¼ g Sine Sweep

X-Axis Sine Sweeps (03 Dec 99) **S/N 108** Accel Location		Accel	1st fn (Hz)	Q	Random PSD Level	Peak 3σ Load	S/N 107* 1st fn (Hz)
2nd Refl. Hsg.	1	17X	131	1.5	0.032	**9.4**	132
	2	17X	134	1.4	0.035	**9.6**	132
	3	17X	135	1.4	0.035	**9.7**	132
Top Panel	1	6X	198	2.2	0.050	**17.5**	205
	2	6X	196	3.3	0.050	**21.4**	204
	3	6X	196	3.4	0.050	**21.7**	204
Reflector	1	A7X	136	17.5	0.036	**35.0**	133
	2	A7X	137	16.6	0.050	**40.1**	133
	3	A7X	137	15.9	0.050	**39.2**	133

*Ref. 4 METSAT S/N 107 Acceptance Unit Responses.

Y-Axis Sine Sweeps (06 Dec 99) **S/N 108** Accel Location		Accel	1st fn (Hz)	Q	Random PSD Level	Peak 3σ Load	S/N 107* 1st fn (Hz)
2nd Refl. Hsg.	1	17Y	109	27.7	0.017	**27.2**	111
Top Panel	1	6Y	109	15.2	0.017	**20.2**	110
Reflector	1	A7Y	159	54.7	0.050	**78.4**	161
Reflector	1	A9Y	159	55.3	0.050	**78.8**	161
Motor	1	20Y	109	42.8	0.017	**33.9**	111

*Ref. 4 METSAT S/N 107 Acceptance Unit Responses.

Y-Axis Sine Sweeps (16 Dec 99)

S/N 108 Accel Location		Accel	1st fn (Hz)	Q	Random PSD Level	Peak 3σ Load	S/N 107* 1st fn (Hz)
2nd Refl. Hsg.	1	17Y	109	27.7	0.017	**27.2**	111
	2	17Y	109	28.6	0.017	**27.7**	109
	3	17Y	109	27.5	0.017	**27.1**	109
Top Panel	1	6Y	109	15.2	0.017	**20.2**	110
	2	6Y	109	15.6	0.017	**20.4**	109
	3	6Y	109	15.3	0.017	**20.2**	109
Reflector	1	A7Y	160	52.4	0.050	**77.0**	161
	2	A7Y	160	58.7	0.050	**81.5**	160
	3	A7Y	160	58.5	0.050	**81.3**	160
Reflector	1	A9Y	160	48.3	0.050	**73.9**	161
	2	A9Y	160	53.8	0.050	**78.0**	160
	3	A9Y	160	31.0	0.050	**59.2**	160
Motor	1	20Y	109	37.1	0.017	**31.5**	111
	2	20Y	109	38.1	0.017	**31.9**	109
	3	20Y	109	36.5	0.017	**31.3**	109

*Ref. 4 METSAT S/N 107 Acceptance Unit Responses.

Z-Axis Sine Sweeps (17 Dec 99)

S/N 108 Accel Location		Accel	1st fn (Hz)	Q	Random PSD Level	Peak 3σ Load	S/N 107* 1st fn (Hz)
2nd Refl. Hsg.	1	17Z	144	10.9	0.044	**31.2**	143
	2	17Z	141	9.9	0.041	**28.4**	141
	3	17Z	141	9.7	0.041	**28.2**	141
Top Panel	1	6Z	144	9.1	0.044	**28.5**	143
	2	6Z	141	8.4	0.041	**26.2**	141
	3	6Z	141	8.3	0.041	**26.0**	141
Reflector	1	A7Z	144	133.7	0.044	**109.4**	148
	2	A7Z	142	165.0	0.042	**117.9**	146
	3	A7Z	142	151.0	0.042	**112.8**	146
Reflector	1	A9Z	166	58.1	0.050	**82.6**	165
	2	A9Z	161	67.9	0.050	**87.9**	162
	3	A9Z	161	60.8	0.050	**83.2**	162

*Ref. 4 METSAT S/N 107 Acceptance Unit Responses.

X-Axis Sine Sweeps (11 Jan 00)

S/N 108 Accel Location		Accel	1st fn	Q	Random PSD Level	Peak 3σ Load	S/N 107* 1st fn (Hz)
2nd Refl. Hsg.	1	17X	134	1.3	0.035	**9.2**	132
	2	17X	133	1.3	0.034	**9.1**	132
	3	17X	134	1.3	0.035	**9.2**	132
Reflector	1	A7X	136	14.3	0.036	**31.6**	133
	2	A7X	136	14.5	0.036	**31.8**	133
	3	A7X	136	14	0.036	**31.3**	133
Baseplate	1	12X	197	3.7	0.125	**35.9**	208
	2	12X	196	2.9	0.123	**31.4**	207
	3	12X	196	3.0	0.123	**32.0**	207

*Ref. 4 METSAT S/N 107 Acceptance Unit Responses.

Z-Axis Sine Sweeps (12 Jan 00)

S/N 108 Accel Location		Accel	1st fn (Hz)	Q	Random PSD Level	Peak 3σ Load	S/N 107* 1st fn (Hz)
2nd Refl. Hsg.	1	17Z	137	7.3	0.037	**23.0**	143
	2	17Z	135	9.8	0.035	**25.8**	141
	3	17Z	136	9.2	0.036	**25.4**	141
Top Panel	1	6Z	137	6.3	0.037	**21.3**	143
	2	6Z	135	8.5	0.035	**24.0**	141
	3	6Z	136	7.9	0.036	**23.5**	141
Reflector	1	A7Z	137	40.9	0.037	**54.3**	148
	2	A7Z	136	135.2	0.036	**97.2**	146
	3	A7Z	136	128.8	0.036	**94.9**	146
Reflector	1	A9Z	163	61.1	0.050	**83.9**	165
	2	A9Z	157	61	0.050	**82.3**	162
	3	A9Z	157	67.5	0.050	**86.6**	162

*Ref. 4 METSAT S/N 107 Acceptance Unit Responses.

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Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
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4. Title and Subtitle Integrated Advanced Microwave Sounding Unit-A (AMSU-A), Engineering Test Report	5. Report Date 13 March 2000
	6. Performing Organization Code ---
7. Author(s) R. Heffner	8. Performing Organization Report No. 11655
	10. Work Unit No. ---
9. Performing Organization Name and Address Aerojet 1100 W. Hollyvale Azusa, CA 91702	11. Contract or Grant No. NAS 5-32314
	13. Type of Report and Period Covered Final
12. Sponsoring Agency Name and Address NASA Goddard Space Flight Center Greenbelt, Maryland 20771	14. Sponsoring Agency Code ---

15. Supplementary Notes

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16. ABSTRACT (*Maximum 200 words*)

This is the Engineering Test Report, AMSU-A2 METSAT Instrument (S/N 108) Acceptance Level Vibration Test of Dec 1999/Jan 2000 (S/O 784077, OC-454), for the Integrated Advanced Microwave Sounding Unit-A (AMSU-A).

17. Key Words (Suggested by Author(s))	18. Distribution Statement
EOS Microwave System	Unclassified --- Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified		---

NASA FORM 1626 OCT 86

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1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED	
4. TITLE AND SUBTITLE Integrated Advanced Microwave Sounding Unit-A (AMSU-A), Engineering Test Report		5. FUNDING NUMBERS NAS 5-32314	
6. AUTHOR(S) R. Heffner			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Aerojet 1100 W. Hollyvale Azusa, CA 91702		8. PERFORMING ORGANIZATION REPORT NUMBER 11655 13 March 2000	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) NASA Goddard Space Flight Center Greenbelt, Maryland 20771		10. SPONSORING/MONITORING AGENCY REPORT NUMBER ---	
11. SUPPLEMENTARY NOTES ---			
12a. DISTRIBUTION/AVAILABILITY STATEMENT ---		12b. DISTRIBUTION CODE ---	
13. ABSTRACT (*Maximum 200 words*) This is the Engineering Test Report, AMSU-A2 METSAT Instrument (S/N 108) Acceptance Level Vibration Test of Dec 1999/Jan 2000 (S/O 784077, OC-454), for the Integrated Advanced Microwave Sounding Unit-A (AMSU-A).			
14. SUBJECT TERMS EOS Microwave System			15. NUMBER OF PAGES 16. PRICE CODE ---
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT SAR

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Engineering Test Report AMSU-A2 METSAT Instrument (S/N 108) Acceptance Level Vibration Tests of Dec 1999/Jan 2000 (S/O 784077, OC-454)			Report 11655 13 March 2000
INPUT FROM: R. Heffner	CDRL: 207	SPECIFICATION ENGINEER: N/A	DATE
CHECKED BY: N/A	DATE	JOB NUMBER: N/A	DATE

APPROVED SIGNATURES	DEPT. NO.	DATE
Product Team Leader (D. Tran) D. Tran	8420	3/13/00
Systems Engineer (R. Platt) Robert H Platt	8410	3/17/00
Design Assurance (E. Lorenz) E. Lorenz	8410	3/17/00
Quality Assurance (R. Taylor) RM Taylor	7831	3-17-00
PMO/Technical (P. Patel) P. K. Patel	8410	3/21/00
Released: Configuration Management (J. Cavanaugh) J. Cavanaugh	8410	3-21-00

By my signature, I certify the above document has been reviewed by me and concurs with the technical requirements related to my area of responsibility.

(Data Center) FINAL