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Report 11652
7 March 2000

AEROJET

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

Engineering Test Report

AMSU-A2 S/N 108 Weight and Center of Gravity Measurements

[redacted]

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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INTEROFFICE MEMO

TO: J. Linn

DATE: 07-March-2000
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FROM: R. Bahng

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SUBJECT: AMSU-A2 S/N 108 Weight and Center of Gravity Measurements.

COPIES TO: J. Christman, A. Nieto, P. Patel, J. Pieper, R. Platt, D. Tran, Electronic File

REFERENCES:

1. IS-2624483, Unique Instrument Interface Specification for the Advanced Microwave Sounding Unit-A2 (AMSU-A2), RCA Corporation Astro-Electronics.
2. S-480-79, Performance Assurance Requirements for the EOS/METSAT Integrated Programs, Goddard Space Flight Center.
3. S-480-80, Performance and Operation Specification for the EOS/METSAT Integrated Programs, Goddard Space Flight Center.
4. AE-26151/3C, Process Specification: Center of Gravity and Weight Test Procedure for the AMSU-A System, GenCorp Aerojet Azusa, May 7, 1999.
5. OC-459 Rev. 2, METSAT AMSU-A Weight and Center of Gravity Test Procedure, GenCorp Aerojet Azusa.
6. Shop Order No. 798168, Center of Gravity and Weight Test Procedure for METSAT AMSU-A2 S/N 108 (P/N 1331200-2-WGT), GenCorp Aerojet Azusa.
7. Drawing No. 1333965, AMSU-A2 Thermal Interface Control and Instrument Configuration Drawing, GenCorp Aerojet Azusa.

PURPOSE

This memorandum for the METSAT (Meteorological Satellites) AMSU-A2 (Advanced Microwave Sounding Unit-A2) Project reports the weight and center of gravity location measurements of the A2 module with serial number 108 (Aerojet part number 1331200-2 Rev. AE). The measurements were performed in order to demonstrate compliance of the A2 module with the Unique Instrument Interface Specification (RCA IS-2624483). The weight and center of gravity measurements will also be used in the documentation of the mass properties of the A2 module. The results of the measurements and their effects on compliance with the Interface Specification will be discussed herein.

SUMMARY

The weight and center of gravity location of the METSAT AMSU-A2 module, with assembly serial number 108, were measured on February 17, 2000 at the Aerojet Azusa environmental testing facility.

The measurements were taken in accordance with Aerojet Process Specification AE-26151/3C and Facility Test Procedure OC-459, Rev. 2. The following measurements were obtained:

Unit under test: AMSU-A2 S/N 108
Weight: 109.98 pounds
X_{A2}: 11.71 inches
Y_{A2}: -11.63 inches
Z_{A2}: 16.56 inches.

The weight of eleven mounting screws and washers were not included in the total weight of the AMSU-A2 S/N 108 unit that is stated above. Although the total weight of these eleven screws and washers, 0.18 pound, is negligible compared to the overall weight of the instrument, it was not included in the weight budget because the bolts are not provided by the supplier (Aerojet) as part of the spacecraft configuration. The center of gravity measurements include the weight of these fasteners because these they are necessary for securing the instrument to the test fixture. The center of gravity location (X_{A2}, Y_{A2}, and Z_{A2}) is relative to the instrument coordinate axes shown in the AMSU-A2 Outline Drawing in the Interface Specification (Reference 1). The instrument coordinate system is also defined in the AMSU-A2 Thermal Interface Control and Interface Configuration Drawing, with Aerojet drawing number 1333965. The A2 module under test was measured with the flight thermal blankets installed. Connector savers and GSE (ground support equipment) were removed from the module during the test.

The Interface Specification for the AMSU-A2 instrument weight states, "the total weight of the AMSU-A2 instrument shall not exceed 110.0 pounds." The weight of the METSAT AMSU-A2 S/N 108 unit, measured to be 109.98 pounds, is in compliance with the Interface Specification on instrument weight (Reference 1, Paragraph 3.2.1.2).

The Interface Specification for center of gravity of the AMSU-A2 instrument states, "the maximum distance from the instrument's mounting surface to the center of gravity for the AMSU-A2 module shall be less than 12.67 inches." The distance from the mounting surface of the instrument to the center of gravity location, X_{A2}, was measured to be 11.71 inches. The measured center of gravity location of the METSAT AMSU-A2 S/N 108 module is also in compliance with the Interface Specification on center of gravity (Reference 1, Paragraph 3.2.1.5).

DISCUSSION

The measurements of the weight and center of gravity location of the METSAT AMSU-A2 S/N 108 module were performed in accordance with Process Specification AE-26151/3C, Test Facility Procedure OC-459 Rev. 2, and Shop Order 798168. An illustration of a typical weight and center of gravity measurement test setup is shown in Figure 1. The test setup utilizes three load cells to measure the weight and center of gravity of the AMSU-A2 module. An overhead crane supports load cell "1." Load cells "2" and "3" are supported by I-beams mounted to the head expander of the Unholtz-Dickie shaker in the vertical position. The three load cells, with supplementary hardware, support a handling fixture with part number T-1291019. An illustration of the handling fixture is shown in Figure 2. The eyebolt attachment locations L1, L2 and L3 are also shown in Figure 2. Shackles, turnbuckles,

lanyards, and eyebolts were used to support the load cells and handling plate. Weight readouts, from each load cell, were obtained from signal conditioners/indicators connected to each load cell.

The calibration of each load cell was verified by measuring the weight of various masses, with known weights, hung from each load cell. Figure 3 shows plots of measured versus applied weight for each load cell. Input weights of 5, 10, 15, 20, 25, 50, 75, 100, and 125 pounds were used to verify the calibration of each load cell. The load cell readouts were recorded on TDS 1 (Test Data Sheet 1) in AE-26151/3C. The verification of load cells 1, 2, 3 shows the largest deviation of the measured from the actual weight to be 0.67%, 0.67%, and -0.67%, respectively. The calibration checks demonstrated that each load cell was capable of measuring weight within the specified test tolerance of 1% given in AE-26151/3C, from 5 pounds up to 125 pounds.

The instrumentation and test procedures were validated through measurements of the weight and center of gravity location of a "calibrated" mass (P/N T-1291014-001) with known mass properties. The placement of the mass relative to the handling fixture is shown in Figure 2. The load cells were initially "zeroed out" with only the mounting hardware attached (excluding the handling fixture and calibrated mass). To measure the weight and center of gravity of the mass, load cell readings were obtained from the four configurations:

1) handling fixture only, horizontal (0°)
2) handling fixture only, tilted 10° about the Y-axis of the plate
3) handling fixture and calibrated mass, horizontal (0°)
4) handling fixture and calibrated mass, tilted 10° about the Y-axis of the plate

The load cell readings were recorded in TDS 3 in AE-26151/3C. The weight and center of gravity calculation formulas are given in the enclosure. The load cell readings and weight and center of gravity results are shown in Table I. Comparisons of the measured and expected weight and center of gravity location are shown in Table III. The measured weight of the calibrated mass, 97.01 pounds, deviates by 0.25% from the expected value of 96.764 pounds. The measured center of gravity location of the calibrated mass is within 0.54 inch of the expected center of gravity location.

The METSAT AMSU-A2 S/N 108 instrument was mounted on the handling fixture. The outline of the AMSU-A2 module on the handling fixture is shown in Figure 2. The instrument was handled in accordance with Aerojet Handling Procedure AE-26357. Cleanliness control, according to AE-26495, and electrostatic control, according to MPI-09-008, were observed. The weight and center of gravity location of the module were measured with the same procedures that were used to measure the mass properties of the calibrated mass. The test data was recorded on TDS 4 in AE-26151/3C. The load cell readings and weight and center of gravity location results are shown in Tables II and III. The center of gravity location was measured to be 11.71, -11.63, and 16.56 inches in the X_{A2}, Y_{A2}, and Z_{A2} coordinate axes, respectively. The weight was measured to be 110.16 pounds, including the eleven mounting screws and washers, using this method. The final weight of the METSAT AMSU-A2 S/N 108 is 109.98 pounds, which *excludes* the eleven mounting screws and washers that weigh 0.18 pound.

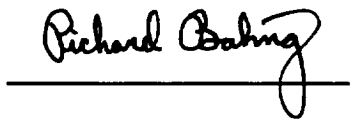
The measured weight and center of gravity location of previously tested AMSU-A2 units are shown in Table IV with the measurement results of the AMSU-A2 S/N 108 discussed herein. The weight of the METSAT-A2 S/N 108 unit differs from the weight of the previously tested METSAT AMSU-A2 units

by less than 0.5 pound. The planar center of gravity locations (Y_{A2} and Z_{A2}) of the METSAT AMSU-A2 units vary by less than 0.10 inch. The vertical center of gravity locations (X_{A2}) of the METSAT AMSU-A2 units vary at the most by approximately 1.28 inches. Previous tests of the calibrated mass, have shown that the vertical center of gravity location (X_{A2}) measurement is most prone to deviate from the actual value. The vertical center of gravity location is difficult to measure because this value is derived from the tilted unit and handling fixture; the vertical center of gravity calculation is very sensitive to the accuracy of the tilt angle. The vertical center of gravity location of the AMSU-A2 S/N 108 unit, measured to be 11.71 inches, is very close to the average value of 11.52 inches based on all METSAT AMSU-A2 units.

The Interface Specification for the AMSU-A2 instrument weight states, "the total weight of the AMSU-A2 instrument shall not exceed 110.0 pounds." The weight of the METSAT AMSU-A2 S/N 108 unit, measured to be 109.98 pounds, is in compliance with the Interface Specification on instrument weight (Reference 1, Paragraph 3.2.1.2). The Interface Specification for center of gravity of the AMSU-A2 instrument states, "the maximum distance from the instrument's mounting surface to the center of gravity for the AMSU-A2 module shall be less than 12.67 inches." The distance from the mounting surface of the instrument to the center of gravity location, measured to be 11.71 inches, is also in compliance with the Interface Specification on center of gravity (Reference 1, Paragraph 3.2.1.5).

CONCLUSIONS/RECOMMENDATIONS

The measured weight and center of gravity location of the METSAT AMSU-A2 S/N 108 module comply with the Interface Specification of mechanical interface. The measured mass properties of the S/N 108 unit agree with those of previously tested METSAT AMSU-A2 units. The agreement of the measured weight and center of gravity location of a calibrated mass with the expected values shows that the test instrumentation and procedures are suitable for measuring the mass properties of the AMSU-A2 module. All aspects of the AMSU-A2 S/N 108 weight and center of gravity test were satisfactory.



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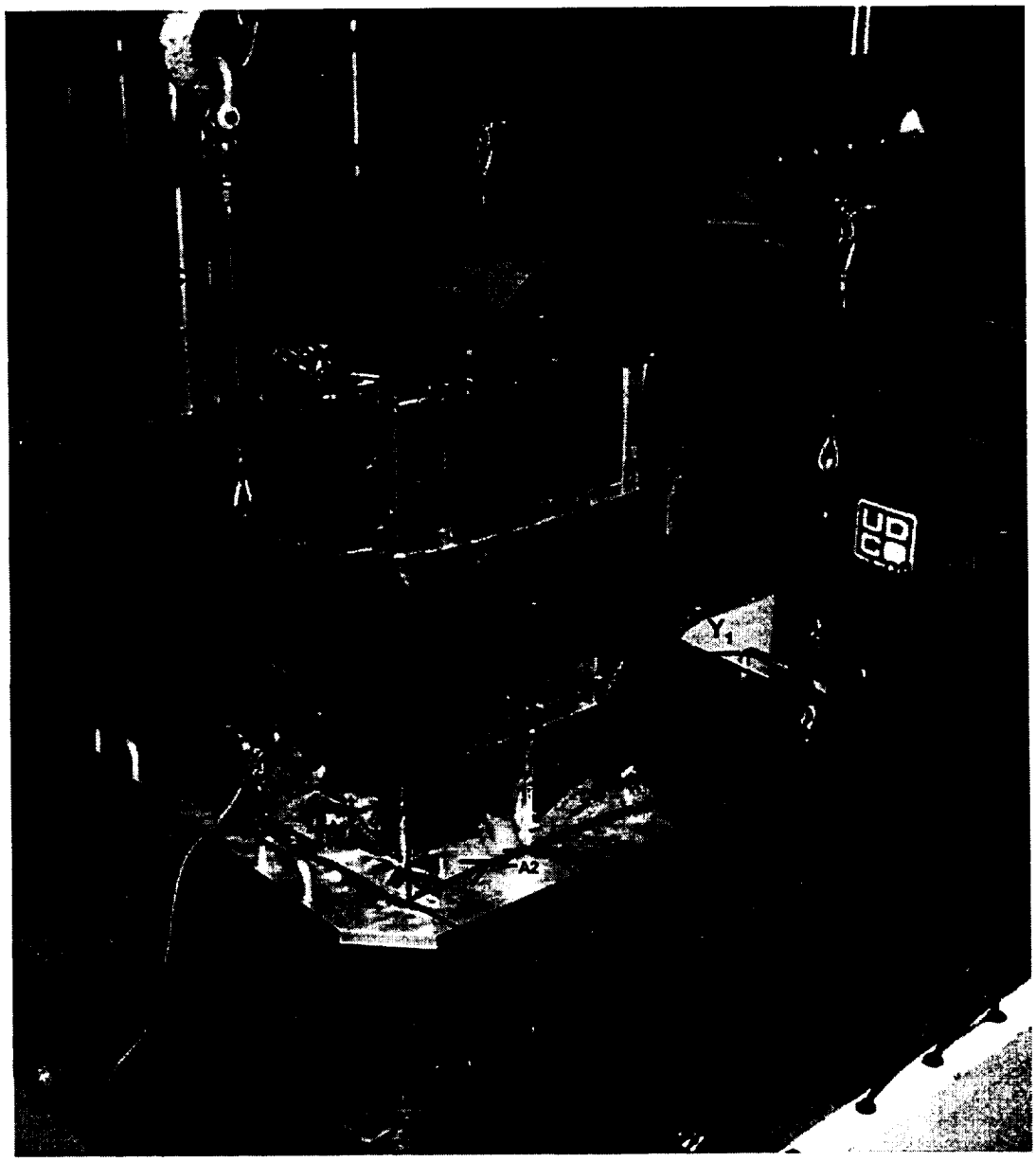

Figure 1. Weight and Center of Gravity Measurement Test Setup.

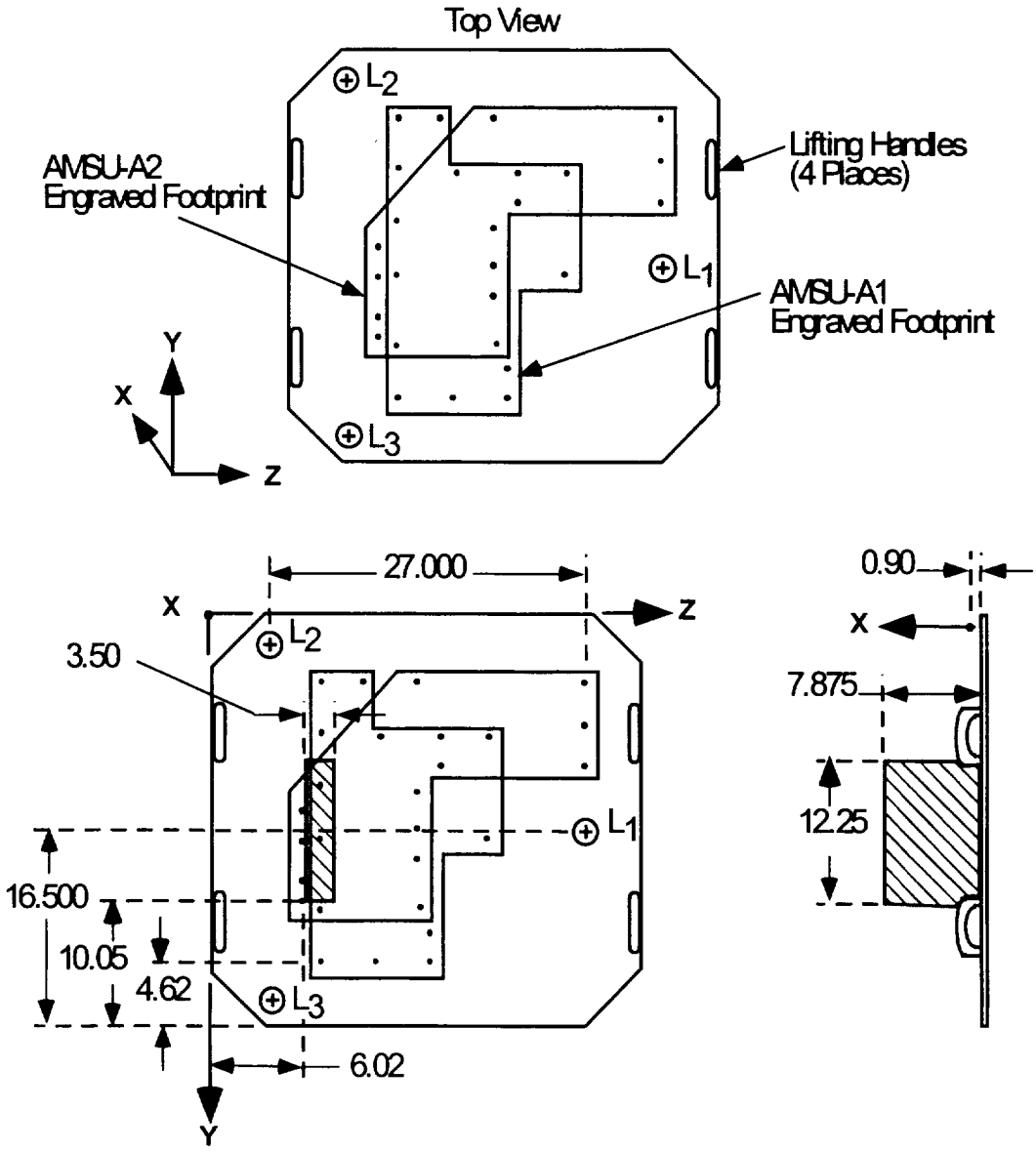

Figure 2. Handling Fixture, 36x33x0.75 inches (above), and Calibrated Mass Location (below).

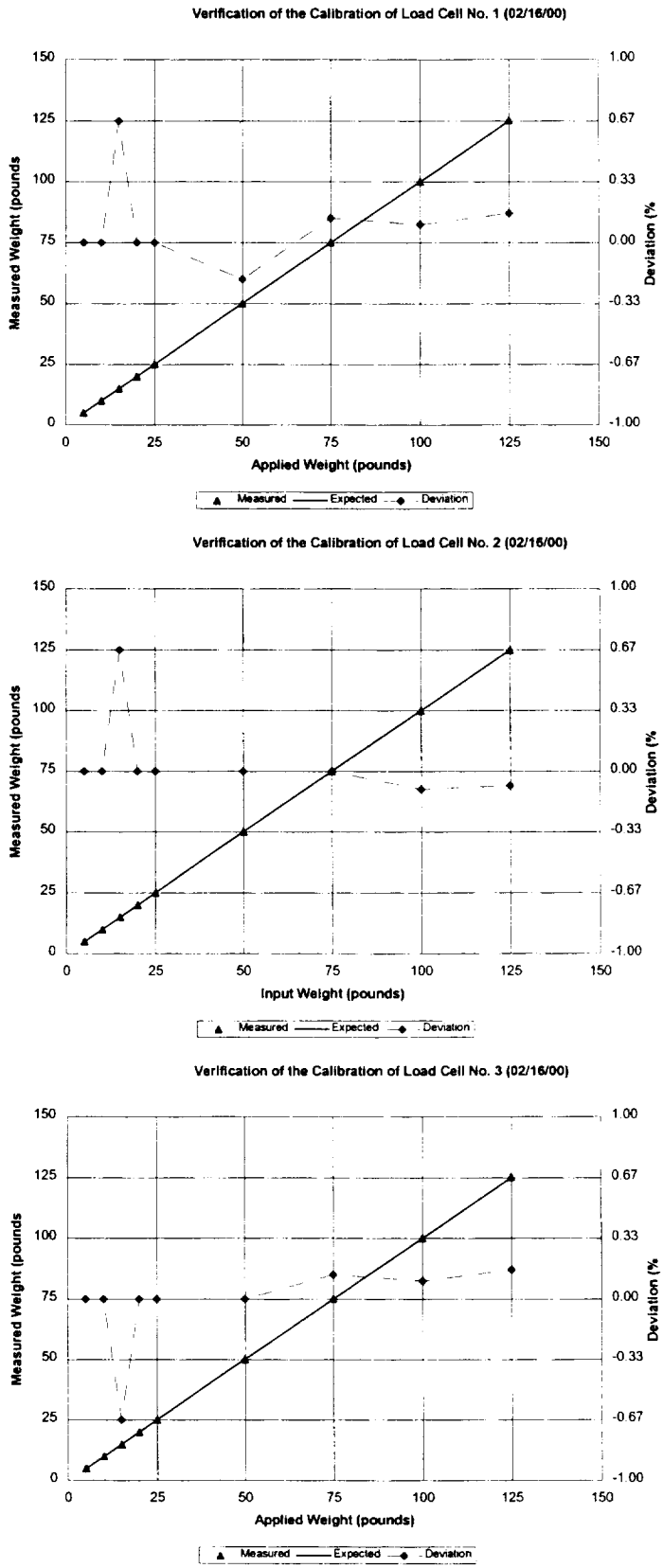

Figure 3. Pretest Load Cell Calibration Checks.

Table I. Calibrated Mass - Weight and CG Calculations

Geometry Point				Load Cell Reading			
Location Of Load Cell	A (in)	b (in)	c (in)	ABC (lbs)	DEF (lbs)	GHI (lbs)	JKL (lbs)
L1	1.15	16.50	31.50	44.65	56.45	45.20	54.90
L2	1.15	2.00	4.50	22.62	64.11	22.39	64.85
L3	1.15	31.00	4.50	22.30	66.02	22.03	66.83
Angle (degree)	10.00		SUM	89.57	186.58	89.62	186.58

Plate's Coord.	Plate (in)	Plate's Coord.	Unit (in)	A1's Coord.	Unit (in)	A2's Coord.	Unit (in)
X2	-0.95	**X1**	3.33	**XA1**	-0.16	**XA2**	4.48
Y2	16.45	**Y1**	16.83	**YA1**	13.89	**YA2**	-13.43
Z2	17.96	**Z1**	7.78	**ZA1**	-4.48	**ZA2**	24.52
Weight (lbs)	89.57		97.01				

Table II. METSAT AMSU-A2 S/N 108 Unit - Weight and CG Calculations

Geometry Point				Load Cell Reading			
Location Of Load Cell	A (in)	b (in)	C (in)	ABC (lbs)	DEF (lbs)	GHI (lbs)	JKL (lbs)
L1	1.15	16.50	31.50	44.65	90.50	45.20	83.45
L2	1.15	2.00	4.50	22.62	60.35	22.39	63.87
L3	1.15	31.00	4.50	22.30	48.88	22.03	52.47
Angle (degree)	10.00		SUM	89.57	199.73	89.62	199.79

Plate's Coord.	Plate (in)	Plate's Coord.	Unit (in)	A1's Coord.	Unit (in)	A2's Coord.	Unit (in)
X2	-0.95	**X1**	10.56	**XA1**	7.80	**XA2**	11.71
Y2	16.45	**Y1**	15.03	**YA1**	12.09	**YA2**	-11.63
Z2	17.96	**Z1**	15.74	**ZA1**	-11.71	**ZA2**	16.56
Weight (lbs)	89.57		110.16				

Table III. Weight and CG Summaries

CG Summary	Axis	Plate Coord. (in) Measured	Plate Coord. (in) Expected	A2 Coord. (in) Measured	A2 Coord. (in) Expected	Discrepancies A2 Coord. Difference	Discrepancies A2 Coord. % Diff.
Calibrated Mass	X	3.33	2.79	4.48	3.94	0.54	13.70
	Y	16.83	16.83	-13.43	-13.43	0.00	0.02
	Z	7.78	7.77	24.52	24.53	-0.01	-0.06
METSAT AMSU-A2 S/N 108	**X**	10.56		11.71			
	Y	15.03		-11.63			
	Z	15.74		16.56			

Weight Summary	Weight (lbs) Measured	Weight (lbs) Expected	Discrepancies Difference	Discrepancies % Diff.
Calibrated Mass	97.01	96.764	0.25	0.25
METSAT AMSU-A2 S/N 108	109.98			

* Final Wt. = Test Wt. – Wt. Of (11) Mounting Screws/Washers = 110.16 – 0.18 = 109.98 lb

Table IV. Database of AMSU-A2 Weight and C. G. (Center of Gravity) Measurements

Spacecraft; Sensor S/N	Aerojet Ref. Memorandum	Weight (lbs)	C. G. X_{A2} (inches)	C. G. Y_{A2} (inches)	C. G. Z_{A2} (inches)
KLM 102	93/12	102.5	11.29	-11.80	16.82
KLM 104	94/19	100.2	11.93	-11.84	16.83
METSAT 105	1999#158	109.5	11.34	-11.64	16.63
METSAT 106	1999#537	110.0	11.73	-11.58	16.66
METSAT 107	1999#318	109.6	10.76	-11.62	16.62
METSAT 108	***2000#295***	***109.98***	***11.71***	***-11.63***	***16.56***
METSAT 109	1999#514	110.0	12.04	-11.54	16.66

Statistics	Weight (lb) Avg. ± Std. Dev.	C. G. X_{A2} (inches) Avg. ± Std. Dev.	C. G. Y_{A2} (inches) Avg. ± Std. Dev.	C. G. Z_{A2} (inches) Avg. ± Std. Dev.
METSAT	**109.81 ± 0.24**	**11.52 ± 0.49**	**-11.60 ± 0.04**	**16.63 ± 0.04**
KLM and METSAT	107.39 ± 4.19	11.54 ± 0.44	-11.66 ± 0.11	16.68 ± 0.10

ENCLOSURE:

Formulae for AMSU-A1 and A2 Weight and Center of Gravity Calculations

a. Location of load cell attachment points (in inches):

(1) a_1, a_2, a_3: location of eyebolts/load cells, measure from the plate to the contact point between the eyebolt and the anchor shackle.
(2) $b_1 = 16.50$; $b_2 = 2.00$; $b_3 = 31.00$: Y location of eyebolts/load cells, in plate coordinate system.
(3) $c_1 = 31.50$; $c_2 = 4.50$; $c_3 = 4.50$: Z location of eyebolts/load cells, in plate coordinate system.
(4) $= 10.0°$ (tilted angle measured from horizontal position)
(5) $a = (a_1+a_2+a_3) / 3$

b. Load cell readings (L_1, L_2, L_3) (in pounds):

(1) A, B, C: plate only, horizontal position (0 degree)
(2) D, E, F: plate and AMSU unit, horizontal position (0 degree)
(3) G, H, I: plate only, tilted to 10 degrees from horizontal.
(4) J, K, L: plate and AMSU unit, tilted to 10 degrees from horizontal.

c. AMSU Weight (in pounds):

(1) Weight = D + E + F - A - B - C

d. AMSU center of gravity in plate coordinate system (in inches):

(1) $X_1 = [(D-A + G-J)\, c_1 + (E-B + H-K)\, c_2 + (F-C + I-L)\, c_3] / (J+K+L-G-H-I) / \tan($
(2) $Y_1 = [(D-A)\, b_1 + (E-B)\, b_2 + (F-C)\, b_3] / (D+E+F-A-B-C)$
(3) $Z_1 = [(D-A)\, c_1 + (E-B)\, c_2 + (F-C)\, c_3] / (D+E+F-A-B-C)$

e. Transformation to A2 coordinate system (in inches):

(1) $X_{A2} = a + X_1$
(2) $Y_{A2} = 3.40 - Y_1$
(3) $Z_{A2} = 32.30 - Z_1$

f. Transformation to A1 coordinate system (in inches):

(1) $X_{A1} = Z_1 - 7.940$
(2) $Y_{A1} = Y_1 - 2.943$
(3) $Z_{A1} = -X_1 - a$

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Report Documentation Page

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13. ABSTRACT (*Maximum 200 words*)

This is the Engineering Test Report, AMSU-A2 S/N 108 Weight and Center of Gravity Measurements, for the Integrated Advanced Microwave Sounding Unit-A (AMSU-A).

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