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Earth Observing System (EOS)
Advanced Microwave Sounding Unit-A (AMSU-A)
Instrumentation Interface Control Document

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Submitted by:

Aerojet
1100 West Hollyvale Street
Azusa, California 91702

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1. SCOPE

This Interface Control Document (ICD) defines the specific details of the complete accommodation information between the Earth Observing System (EOS) PM Spacecraft and the Advanced Microwave Sounding Unit (AMSU-A) Instrument. This is the first submittal of the ICD; it will be updated periodically throughout the life of the program. The next update is planned prior to Critical Design Review (CDR).

1.1 *Description*

AMSU-A is a passive microwave radiometer used on EOS to measure atmospheric temperature profiles as a function of altitude and to estimate atmospheric water content. It contains 15 channels. Channels 1, 2, and 15, at 23.8, 31.4, and 89.0 GHz respectively, provide water content estimation data. Channels 3 through 14, between 50.3 and 57.6 GHz in the oxygen absorption bands of the atmosphere provide temperature profile data.

Channels 1 and 2 are contained in one AMSU-A module, denoted A2, and Channels 3 through 15 are contained in a second module, denoted A1. Each module contains step-scanned antennas, rotating continuously and making measurements in thirty beam positions around nadir. A1 contains two antennas; A2 contains one.

1.2 *Heritage*

The AMSU-A modules are scientifically identical and physically and functionally very similar to AMSU-A modules developed by Aerojet for flight on NOAA-K, -L, and M. Some data provided herein reflect measurements made on that system pending completion of design and test of the EOS/AMSU-A.

2. APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of this ICD to the extent specified herein. In the event of conflict between the detailed context of this ICD and a referenced document, the detailed context of this ICD shall have precedence.

2.1 *Government documents*

		Ref in Para.
SPECIFICATIONS		
Military		
MIL-P-27401C Not. 1 22 Aug 88	Propellant, Pressurizing Agent, Nitrogen	7.5
STANDARDS		
Military		
MIL-STD-1246B 04 Sep 87	Product Cleanliness Levels and Contamination Control Program	7.1
MIL-STD-1553B Notice 2 08 Sep 86	Digital Time Division Command/ Response Multiplex Data Bus	5.4

2.2 *Non-government documents*

2.2.1 *Aerojet documents*

TBD 6	A1 Instrument Thermal Interface Control and Instrument Configuration Drawing	4.3
TBD 5	A2 Instrument Thermal Interface Control and Instrument Configuration Drawing	4.3
TBD 1	A1 Instrument Drill Template	3.4.5
TBD 2	A2 Instrument Drill Template	3.4.5

(Copies of Aerojet documents required by suppliers in connection with specific procurement functions should be obtained from Aerojet, CAGE 70143, P.O. Box 296, Azusa, CA 91702-0296.)

2.2.2 *American National Standards Institute*

ANSI-STD-Y14.5M 1982	Dimensioning and Tolerancing	3.4.2.1

(Copies of ANSI documents may be obtained from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, NY 10017.)

3. MECHANICAL REQUIREMENTS

Because EOS/AMSU-A has a heritage traceable to the NOAA/AMSU-A instruments, dimensioning as used in this document shall be in the English units of inches, the original system of measurement.

3.1 ***Instrument envelopes***.- The EOS AMSU-A1 module mechanical envelope is shown in Figure 1. The A2 module mechanical envelope is shown in Figure 2. The envelope dimensions on these figures are not-to-exceed dimensions that include allowance for multi-layered insulation (MLI). The launch mode envelopes of the AMSU-A modules are identical with the on-orbit envelopes.

3.2 ***Fields of view***.- The fields of view required for the AMSU-A1 module are as shown in Figure 3. The fields of view required for the AMSU-A2 module are as shown in Figure 4.

3.3 *Mass properties*

3.3.1 ***Instrument mass***.- The AMSU-A1 total instrument mass is predicted to be 90 kg and shall not exceed 110 kilograms (kg). The mass of the A1 module is predicted to be 49 kg and shall not exceed 60 kg and the mass of the A2 module is predicted to be 41 kg and shall not exceed 50 kg. (The mass of each delivered module shall be measured to ± 0.1 kg. The measured mass shall be included in the documentation delivered with each module.)

3.3.2 ***Instrument mass variability***.- There are no expendable masses or measurable mass expulsion rates on either module.

3.3.3 ***Instrument center of mass***.- The centers of mass for each module, referenced to the instrument origins and coordinate systems shown in Figures 1 and 2, are predicted to be as shown below. (The calculated centers of mass are within ±25 millimeters (mm) of the values shown.)

	A1 Module	A2 Module
X (mm)	-298	-211
Y (mm)	-159	+337
Z (mm)	+231	+315

3.3.4 ***Moments of inertia***.- The moments of inertia at the center of mass, about axes parallel to the axes shown in Figures 1 and 2, is predicted to be as shown below. (The calculated moments of inertia are within 10% of the values shown.)

	A1 Module	A2 Module
Ixx (kg-m^2)	+2.0	+2.6
Iyy (kg-m^2)	+3.5	+2.4
Izz (kg-m^2)	+2.6	+2.4

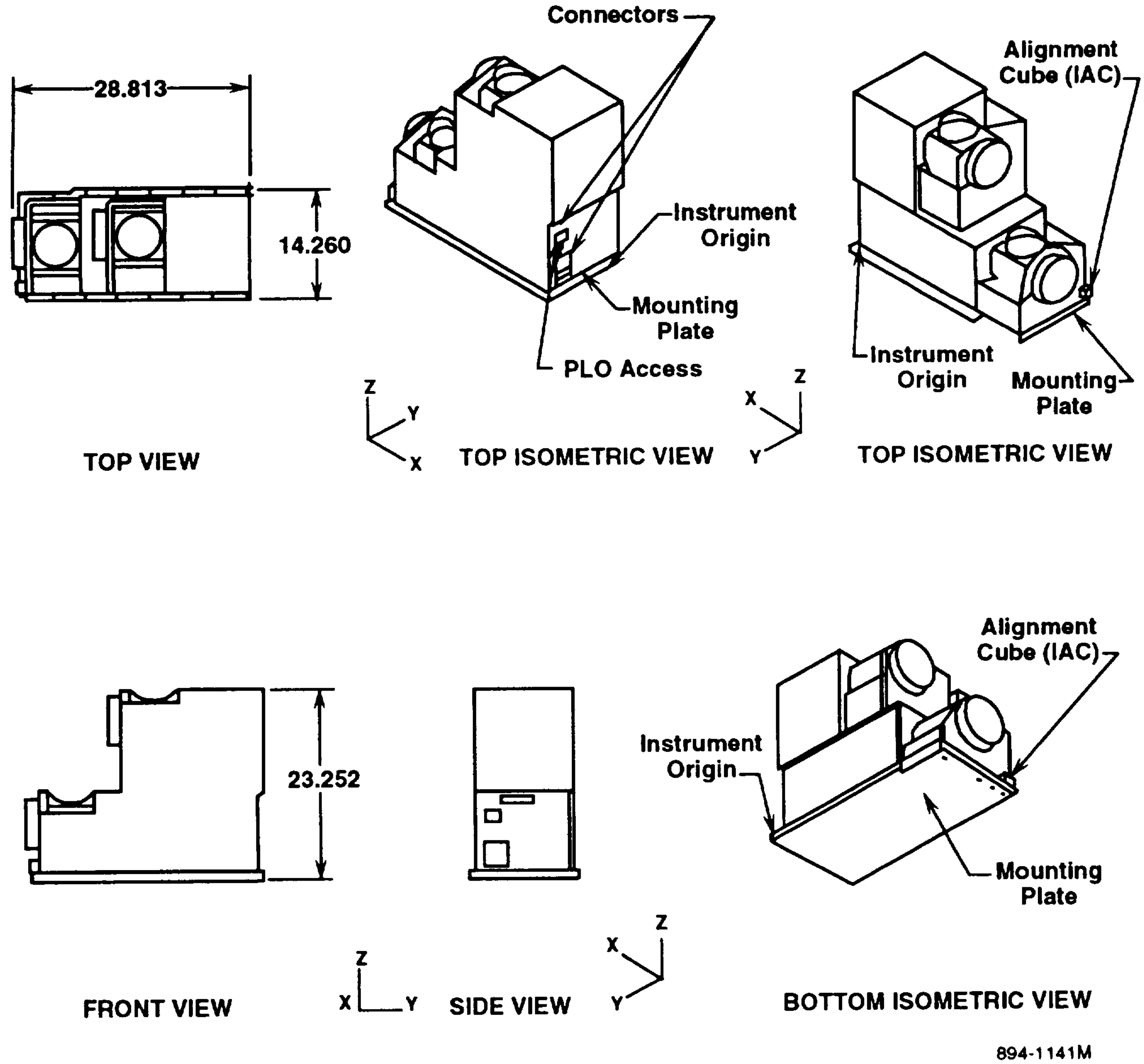


Figure 1 AMSU-A1 Mechanical Envelope

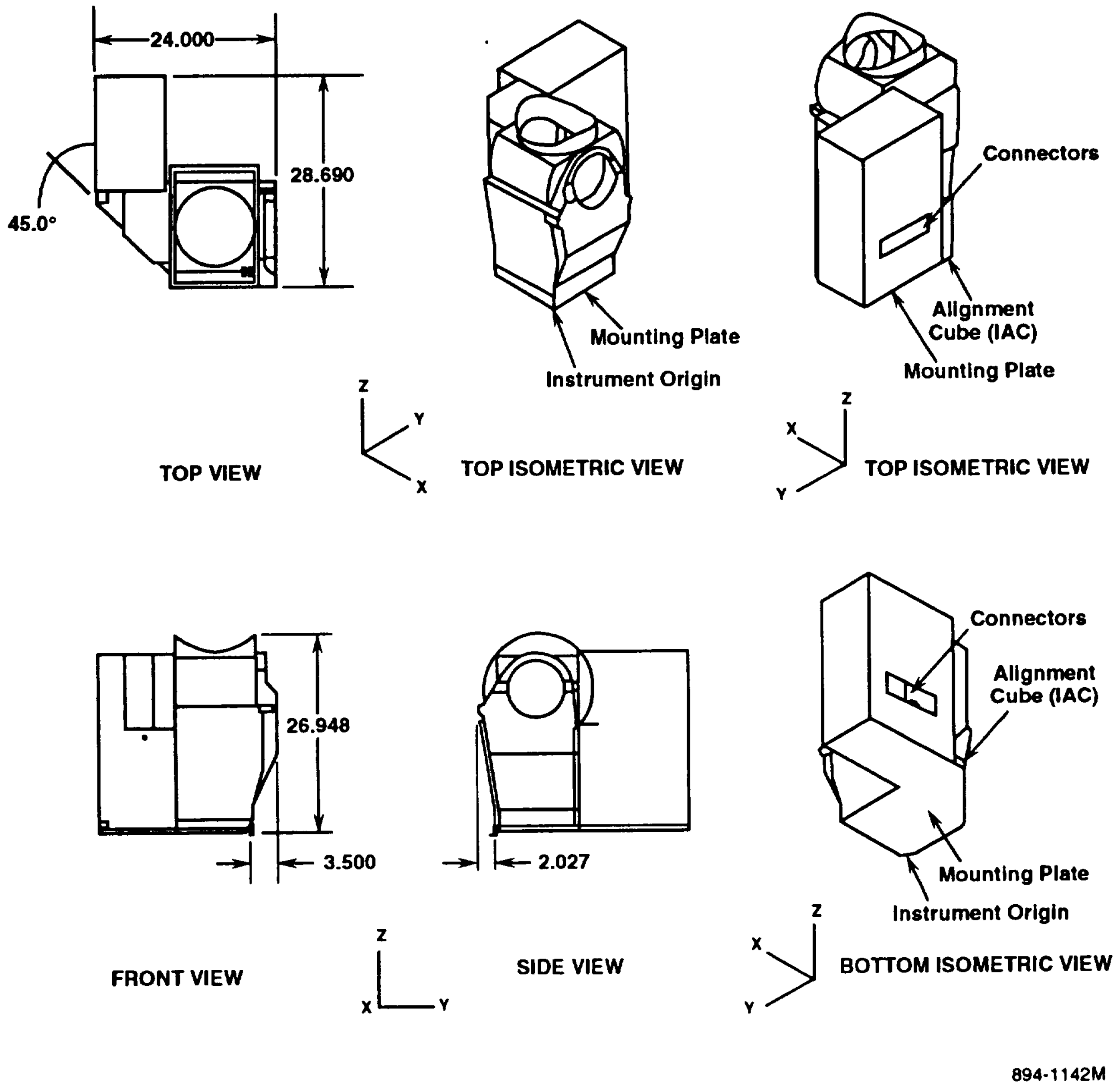


Figure 2 AMSU-A2 Mechanical Envelope

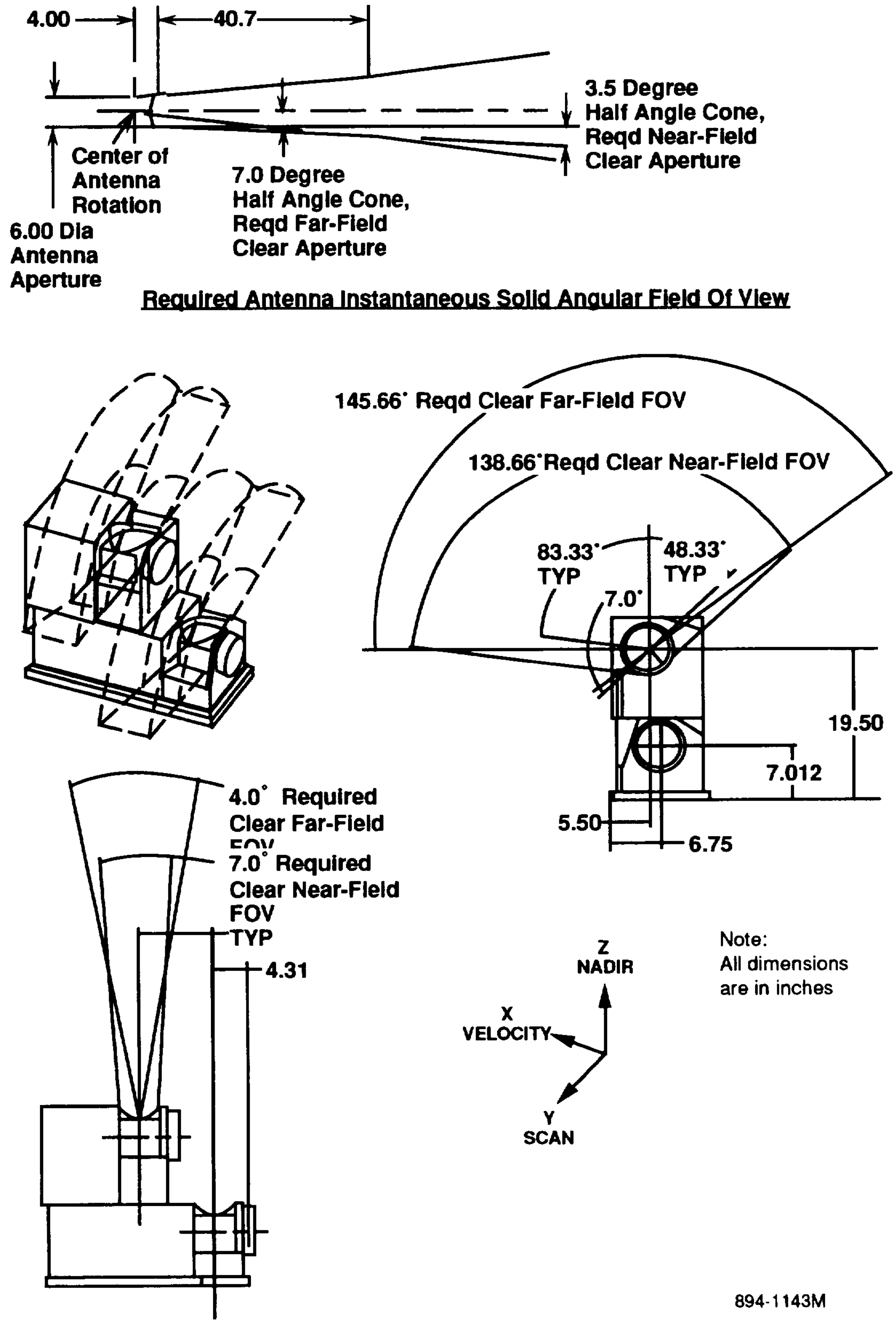


Figure 3 AMSU-A1 Field Of View Requirements

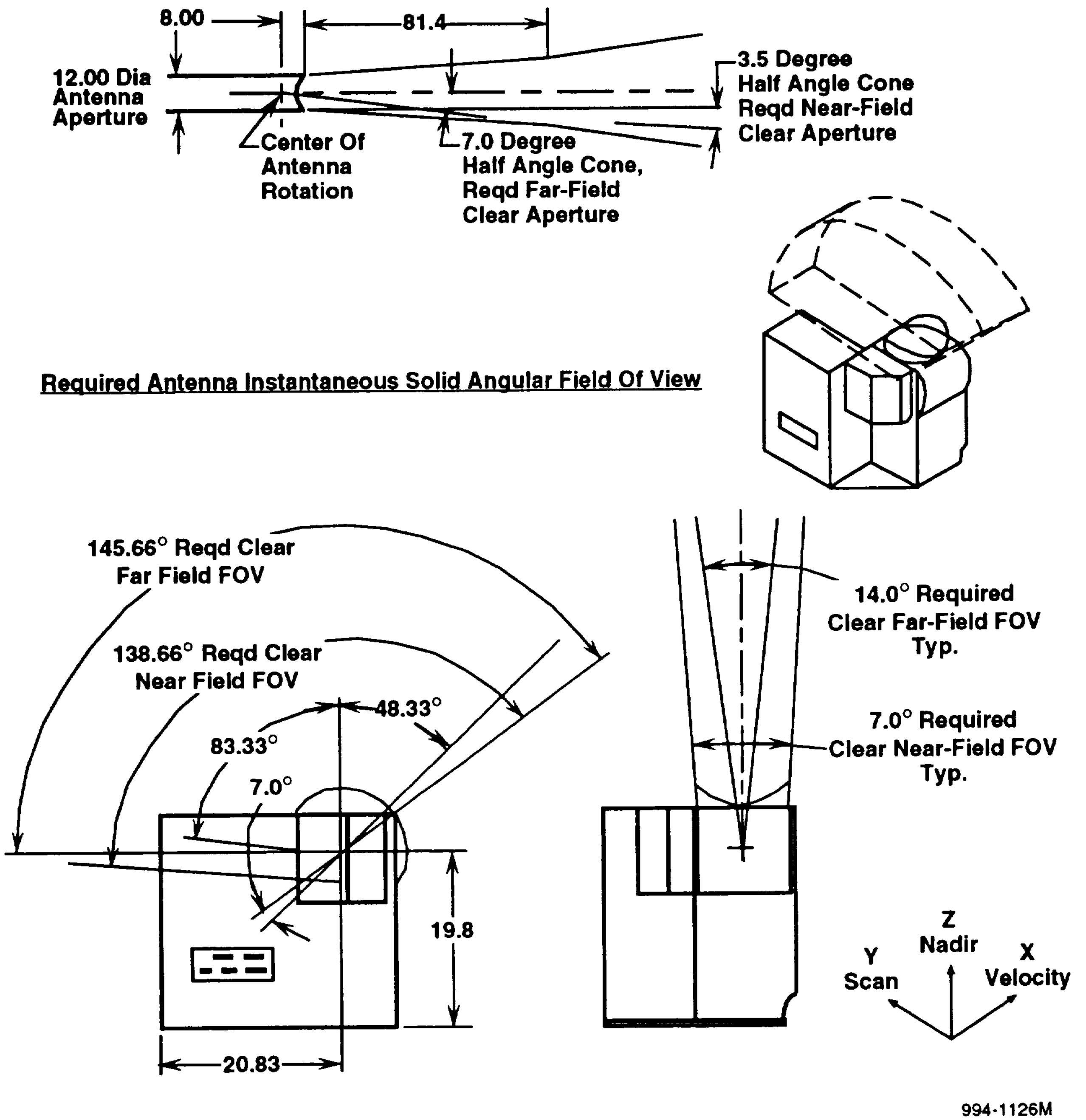


Figure 4 AMSU-A2 Field of View Requirements

3.3.5 ***Products of inertia.***- Products of inertia at the center of mass are defined as:

$$Ixy = \int x\ y\ dm$$

where x and y are distances from the center of mass parallel to the coordinate axes shown in Figures 1 and 2 to the element of mass, dm.

The products of inertia at the centers of mass are predicted to be as shown below. (The calculated moments of inertia are within ± 20% of the values shown.)

	A1 Module	A2 Module
Ixy (kg-m^2)	+0.8	-1.2
Ixz (kg-m^2)	+0.0	+0.0
Iyz (kg-m^2)	+0.0	+0.0

3.4 ***Mounting***

3.4.1 ***Mounting methods.***- Each AMSU-A module shall be mounted to the spacecraft with multiple threaded fasteners passing through the AMSU baseplates into threaded inserts in the spacecraft. Two locating pins in each module are provided to provide precise alignment with the spacecraft. Kinematic mounts are not used with the AMSU-A modules.

3.4.2 ***Mounting holes and dimensions***

3.4.2.1 ***Hole patterns.***- The mounting bolt holes and locating pin locations shall be as shown in Figure 5 for the A1 module and as shown in Figure 6 for the A2 module. (Mounting hole location tolerances shall be interpreted in accordance with ANSI Standard Y14.5M.)

3.4.2.2 ***Hole dimension.***- Both the A1 and A2 modules shall provide for mounting with No. 10 (0.190 inch diameter) bolts. Thermal isolators are incorporated into the AMSU-A modules at the mounting bolt locations. The thermal isolators provide a separation of 0.062 inch between the spacecraft surface and the aluminum baseplate of each module. The dimensions defining the contact area with the spacecraft are as shown in Figure 7. The locating pin dimensions are as shown on Figure 8.

3.4.2.3 ***Interface planes.***- Each AMSU-A module requires that the interface plane, defined at the spacecraft end of the thermal isolators, be flat to within 0.002 inch. The spacecraft contractor shall supply mounting shims that will limit the installation gap between each thermal isolator and the corresponding spacecraft mounting pad to 0.001 inch. After installation of the AMSU-A modules to the spacecraft, the spacecraft mounting plane shall remain flat to within 0.005 inch. This shall apply to launch deflections as well as to on-orbit thermal distortions.

3.4.3 ***Mounting hardware.***- The mounting hardware is described in English units (inches) because EOS/AMSU-A has heritage to the NOAA/AMSU-A instruments. The spacecraft contractor will provide all instrument mounting hardware. The mounting hardware is defined as

a. No. 10 (0.190 inch dia) Socket Head Cap Screws capable of withstanding 85 inch-pounds (in.-lbs.) of installation torque,

b. No. 10 metal washers,

c. Fiberglass thermal washers.

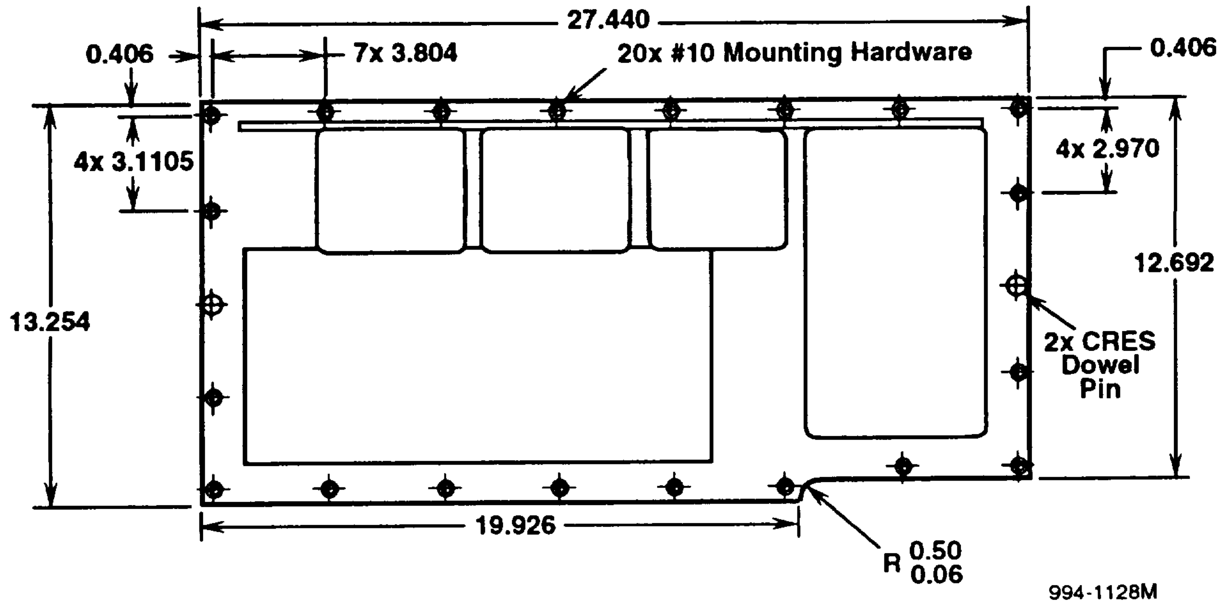


Figure 5 AMSU-A1 Mounting Hole Pattern

The final assembly of the mounting hardware as it relates to the AMSU-A instruments shall be as shown in Figure 9. The required dimensions of the fiberglass thermal washers are shown on Figure 10.

3.4.4 ***Mounting sequence***.- Each AMSU-A module is to be installed using a specified torquing sequence. The torquing sequence to be used for installing A1 is shown in Figure 11. The torquing sequence for A2 is shown in Figure 12.

3.4.5 ***Drill template***.- Aerojet will provide drill templates for locating the bolt hole and shear pin locations on the instruments. Aerojet will provide drill templates to the spacecraft contractor for locating the interface on the spacecraft. The drill templates shall contain optical cubes referenced to the Instrument Alignment Cubes. The drill templates for the A1 and A2 instruments are described on Aerojet drawings TBD 1 and TBD 2, respectively.

3.5 *Alignment*

3.5.1 ***Interface alignment cube locations***.- The locations of the interface alignment cubes (IAC) for the A1 and A2 modules are shown in Figures 1 and 2. The optical alignment cubes are positioned parallel to the instrument coordinate system. The desired 1.5° rotation from the +X axis toward the -Y axis will be accomplished by the spacecraft integrator during drill template alignment.

3.5.2 *Pointing accuracy allocation*

3.5.2.1 ***Spacecraft allocation***.- From the instrument interface cube to the Earth frame of reference, the pointing accuracy errors in arc seconds, 3 sigma values shall be less than:

a.	pointing accuracy	720/axis
b.	pointing stability	360/sec/axis
c.	pointing knowledge	360/axis

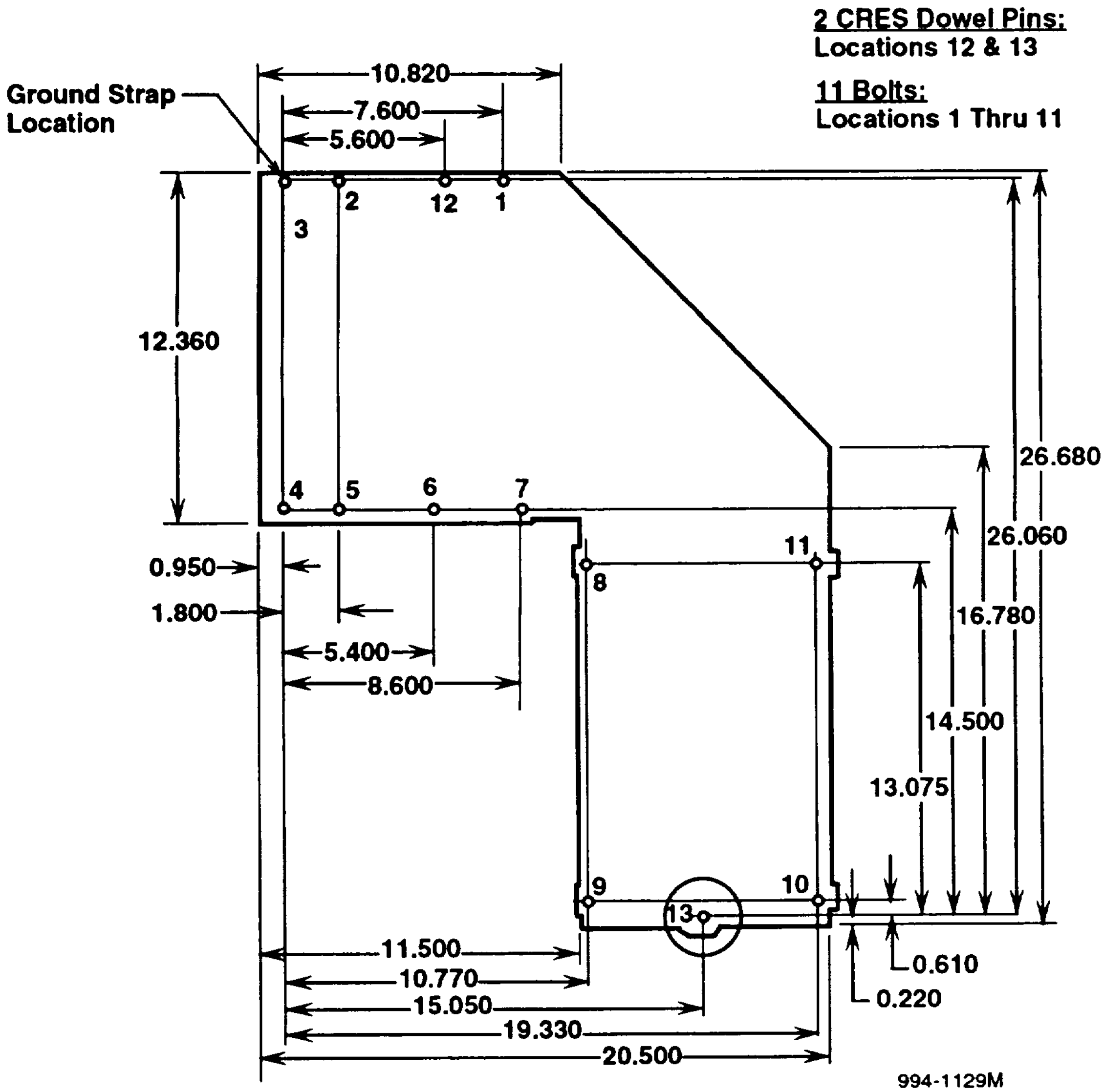


Figure 6 AMSU-A2 Mounting Hole Pattern

3.5.2.2 ***Instrument allocation***.- From the instrument boresight to the instrument interface cube, the pointing accuracy errors in arc seconds, 3 sigma values, shall be less than:

a.	pointing accuracy	720/axis
b.	pointing stability	180/sec/axis
c.	pointing knowledge	360/axis

3.5.2.3 ***Alignment angles***.- The measured alignment angle between the instrument IAC and the instrument boresight will be included in the documentation delivered with each unit.

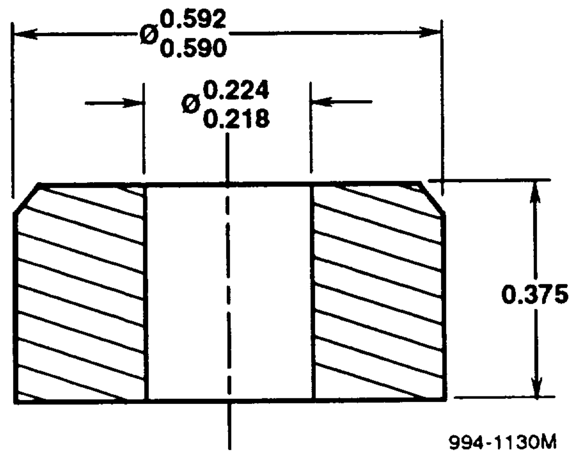


Figure 7 Thermal Isolator Dimensions, A1 & A2

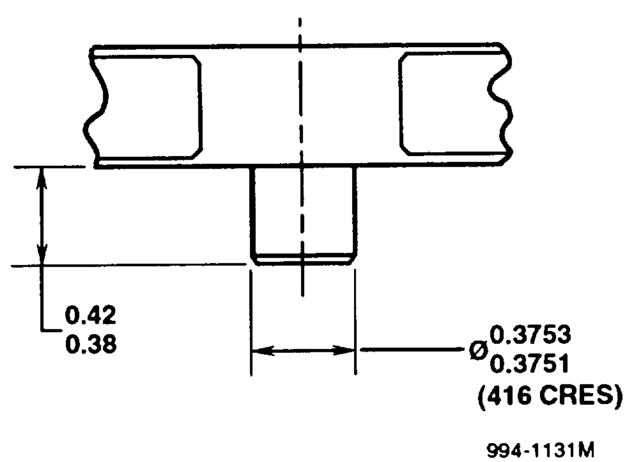


Figure 8 Locating Pin Dimensions, A1 & A2

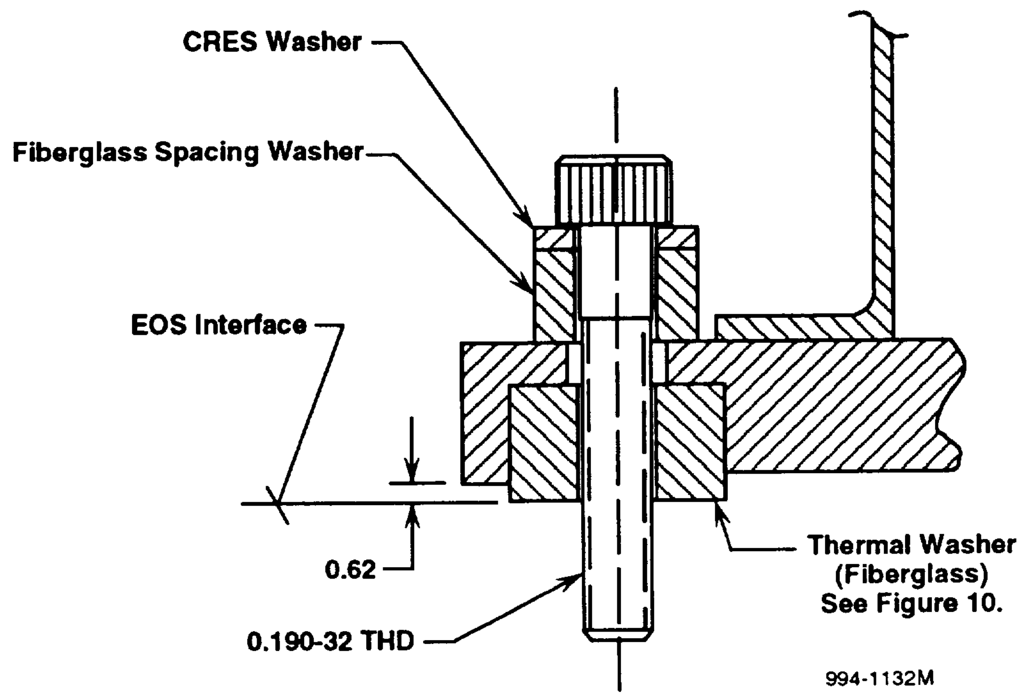


Figure 9 AMSU-A Mounting Hardware

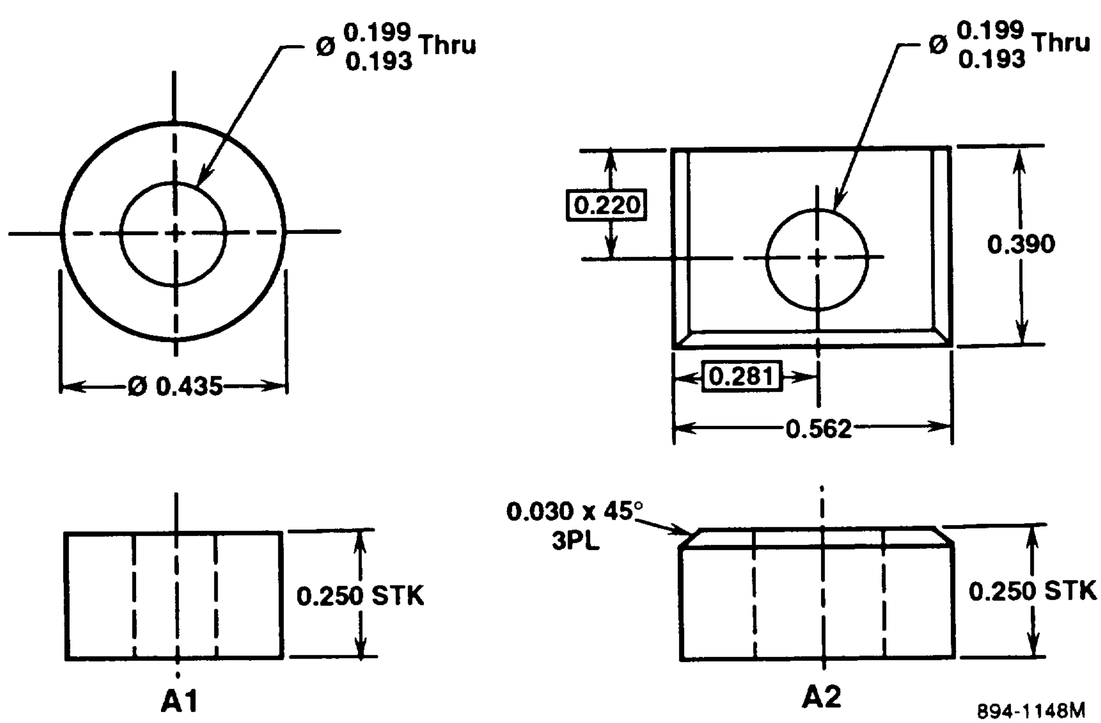
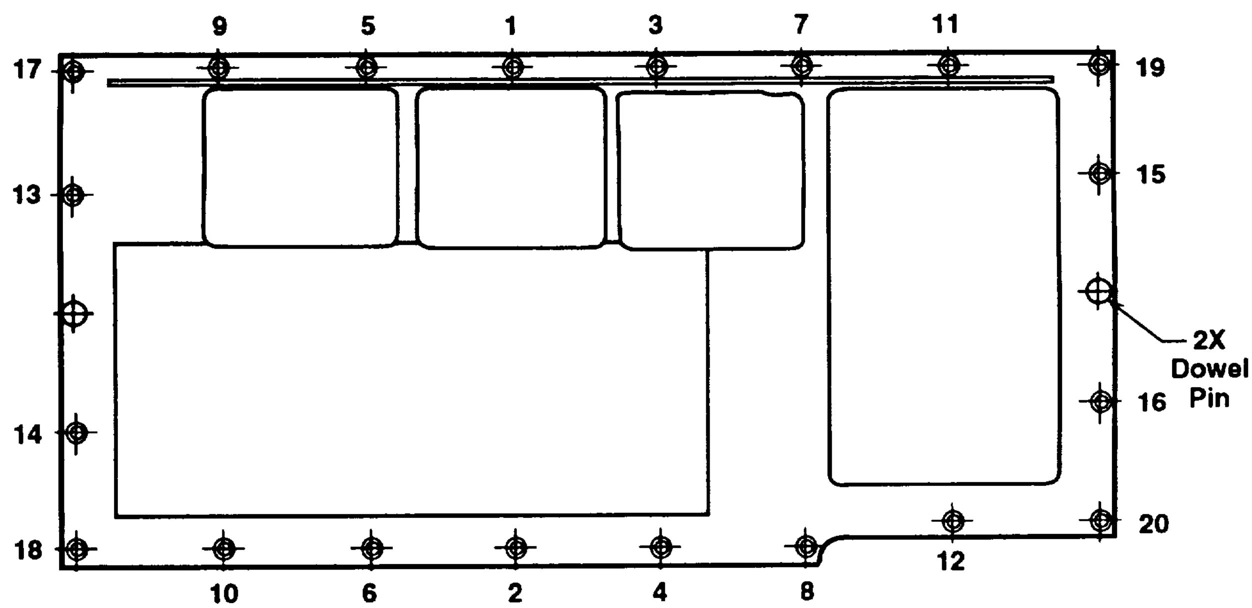


Figure 10 Thermal Washer Dimensions

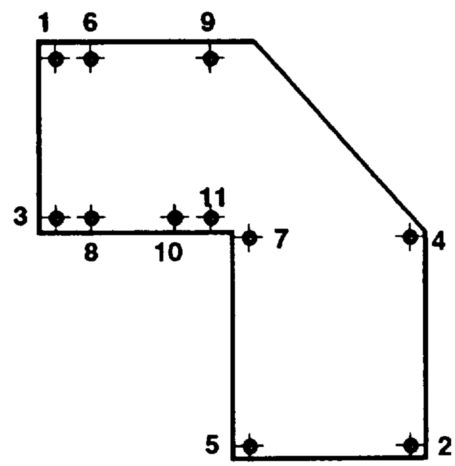


Incremental torque values:

1. Torque screws to 20.0 ± 2.0 in-lbs in the order shown
2. Torque screws to 30.0 ± 2.0 in-lbs in the order shown
3. Torque screws to 40.0 ± 2.0 in-lbs in the order shown
4. Torque screws to 50.0 ± 2.0 in-lbs in the order shown
5. Torque screws to 60.0 ± 2.0 in-lbs in the order shown
6. Torque screws to 70.0 ± 2.0 in-lbs in the order shown
7. Torque screws to 83.0 ± 2.0 in-lbs in the order shown

994-1134M

Figure 11 A1 Torquing Sequence



Incremental torque values:

1. **Torque screws to 20.0 ± 2.0 in-lbs in the order shown**
2. **Torque screws to 30.0 ± 2.0 in-lbs in the order shown**
3. **Torque screws to 40.0 ± 2.0 in-lbs in the order shown**
4. **Torque screws to 50.0 ± 2.0 in-lbs in the order shown**
5. **Torque screws to 60.0 ± 2.0 in-lbs in the order shown**
6. **Torque screws to 70.0 ± 2.0 in-lbs in the order shown**
7. **Torque screws to 83.0 ± 2.0 in-lbs in the order shown**

994-1135M

Figure 12 A2 Torquing Sequence

3.6 *Disturbance*

3.6.1 ***Torque profile.***- The disturbance torque of the AMSU-A instruments is generated by the step scan motion of the scan drive motors. These motors are current limited and have a known maximum torque to current ratio. The peak torque from the A1 instrument is limited to less than 315 inch-ounces. The torque magnitude spectrum of each instrument is TBD.

Interface Connector Designation	Connector Function
J1	Power Input
J2	Passive Analog
J3	1553 Bus
J4	Test Output And GSE Command Input
J5	RT Address Select Plug

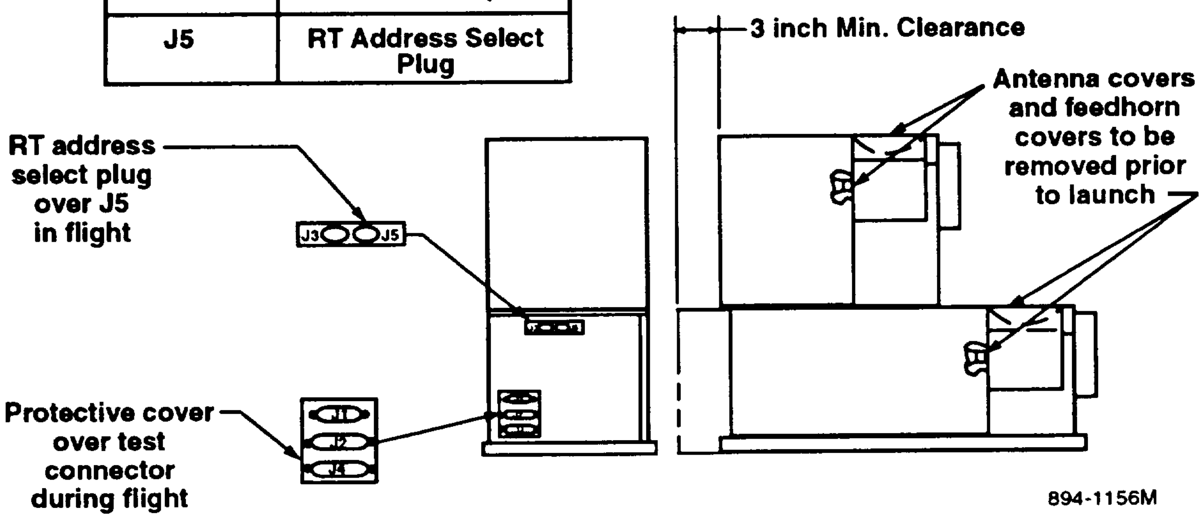


Figure 13 AMSU-A1 Connector Location and Access Requirements

3.6.2 *Angular momentum*.- Steady state angular momentum reacted from the instrument to the spacecraft shall be less than 0.5 Newton-meter-second (N-m-sec) per axis. The steady state angular momentum imparted by the A1 instrument in its coordinate system is as follows:

a.	X axis	TBD ± TBD % N-m-sec
b.	Y axis	TBD ± TBD % N-m-sec
c.	Z axis	TBD ± TBD % N-m-sec

The steady-state angular momentum imparted by the A2 instrument in its coordinate system is as follows:

d.	X axis	TBD ± TBD % N-m-sec
e.	Y axis	TBD ± TBD % N-m-sec
f.	Z axis	TBD ± TBD % N-m-sec

Interface Connector Designation	Connector Function
J1	Power Input
J2	Passive Analog
J3	1553 Bus
J4	Test Output And GSE Command Input
J5	RT Address Select Plug

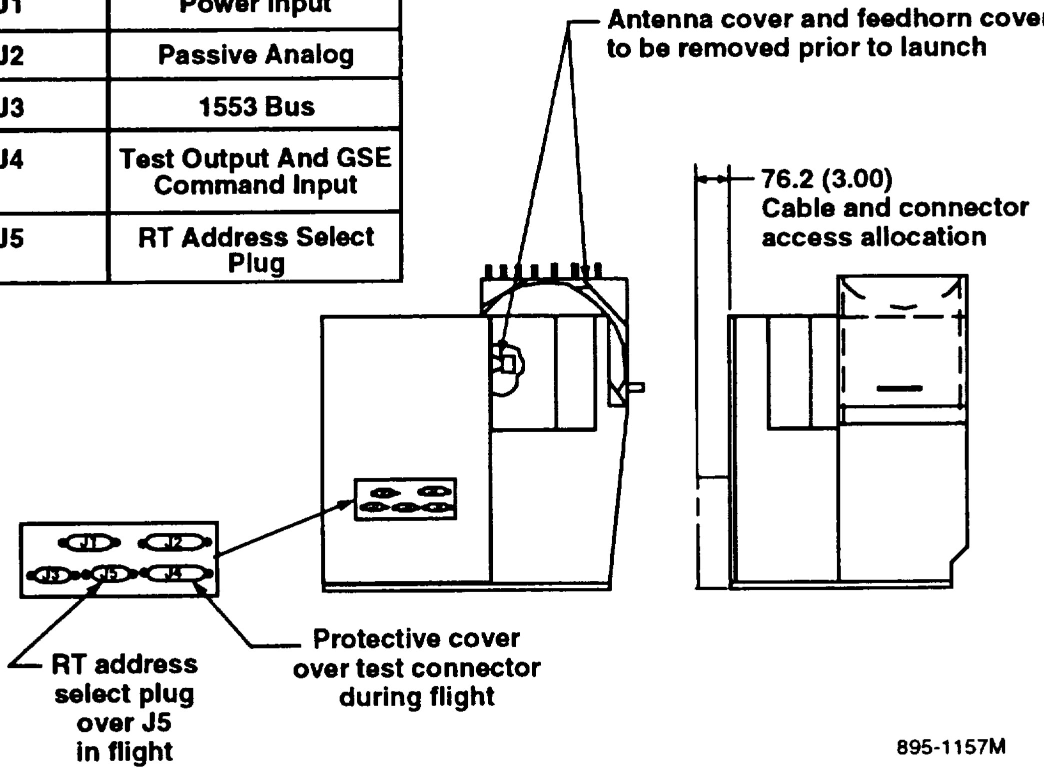


Figure 14 AMSU-A2 Connector Location and Access Requirement

3.7 *Access requirements.*- Access requirements for the A1 and A2 modules are shown in Figures 13 ad 14 respectively. A minimum of three inches clearance is required for cable installation and connector access in the areas indicated.

3.8 *Non-flight equipment*

3.8.1 *Observatory level test/calibration equipment*- The instrument supplier shall provide the external cold targets required for calibration.

a. AMSU-A1 Target Assembly
b. AMSU-A2 Target Assembly

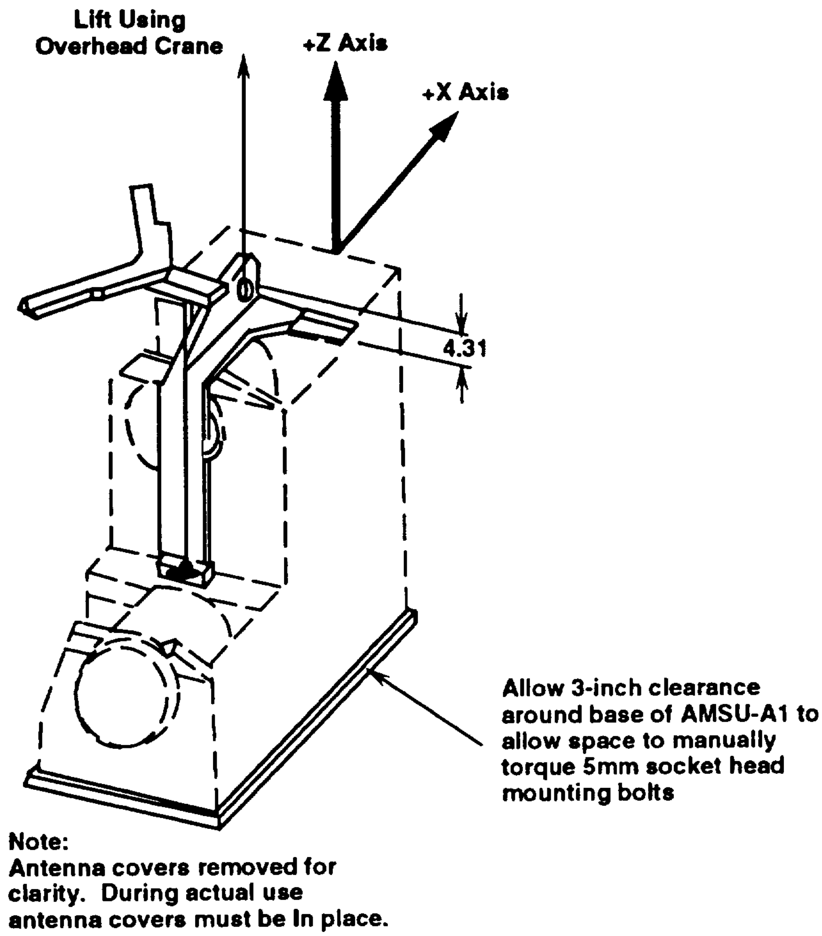


Figure 15 AMSU-A1 Hard Point Locations and Handling Fixtures

3.8.2 ***Mechanical GSE***.- The spacecraft integrator shall provide the associated liquid nitrogen supply and the external cold target mounting fixtures.

The following mechanical GSE will be provided by the instrument provider.

a. AMSU-A1 Spacecraft Integration Fixture (See Figure 15)
b. AMSU-A2 Spacecraft Integration Fixture (See Figure 16)
c. AMSU-A1 Mounting Template
d. AMSU-A2 Mounting Template
e. AMSU-A1 Shipping / Storage Container
f. AMSU-A2 Shipping / Storage Container
g. AMSU-A1 Handling Plate (See Figure 17)
h. AMSU-A2 Handling Plate (See Figure 17)

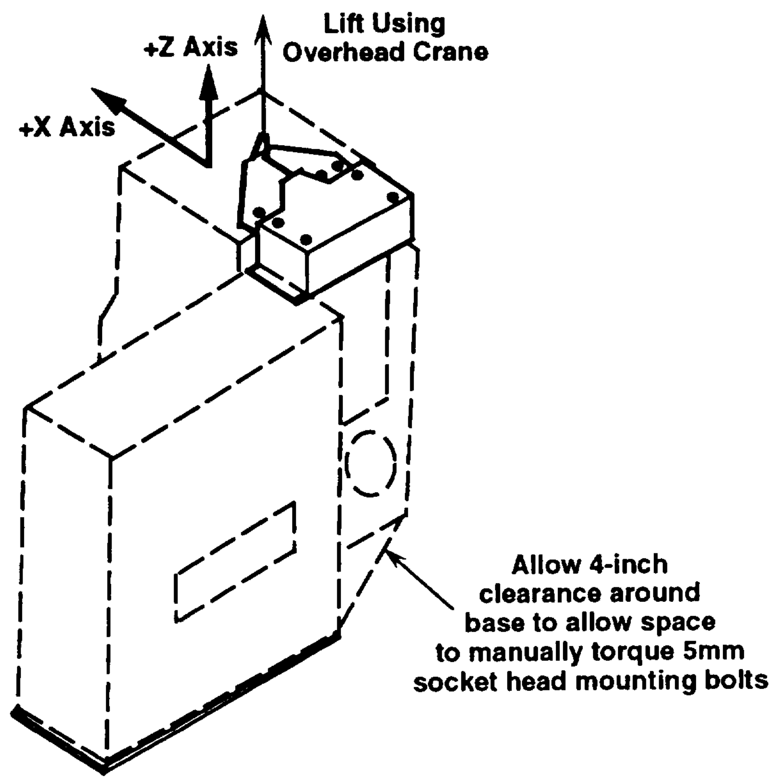


Figure 16 AMSU-A2 Hard Point Locations And Handling Fixtures

3.8.3 *Electrical GSE*.- The instrument provider will provide the equipment necessary for pre-integration check-out and troubleshooting as well as the capability to monitor instrument health through a listen-only connection to the spacecraft GSE.

a. Items to be removed — Procedure

1. Aperture Covers — TBD
2. Feedhorn Covers — TBD

b. Items to be installed — Procedure

None — N/A

3.8.4 ***Equipment removed prior to flight***.- Location of the items to be removed are shown in Figures 13 and 14. Each of the items below will be tagged with a red tag stating "Remove before flight."

AMSU-A1	Antenna Covers, Qty. 2
AMSU-A2	Antenna Covers, Qty. 1
AMSU-A1	Feedhorn Covers, Qty. 2
AMSU-A2	Feedhorn Covers, Qty. 1

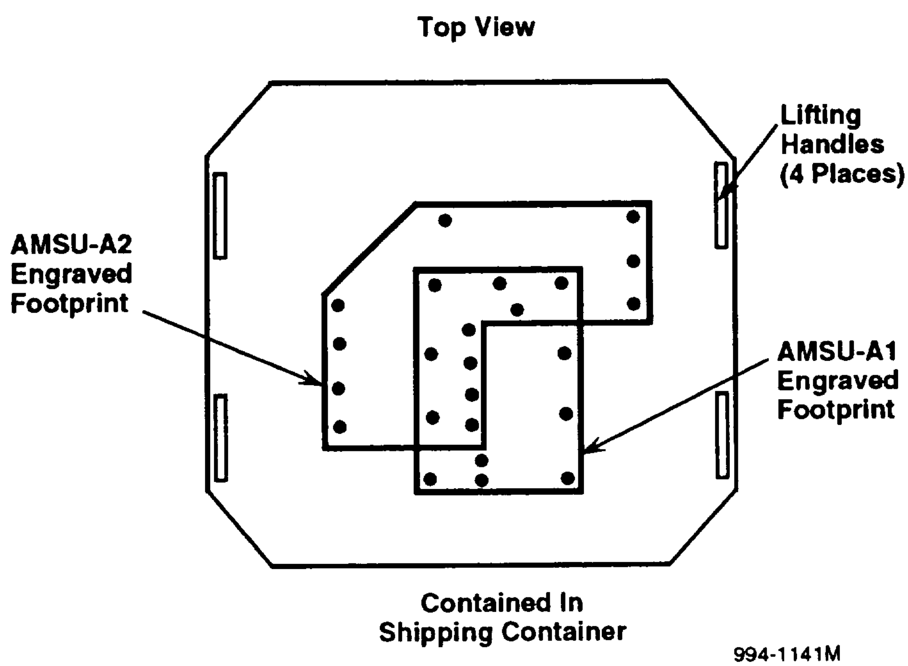


Figure 17 AMSU-A1 And AMSU-A2 Handling Plate

3.8.5 ***Equipment installed prior to flight***.- The following items are to be installed prior to flight.

AMSU-A1	Alignment Cube Cover, Qty 1
AMSU-A2	Alignment Cube Cover, Qty 1
AMSU-A1	J4 Test Connector Protective Cover, Qty. 1
AMSU-A2	J4 Test Connector Protective Cover, Qty. 1
AMSU-A1	J5 RT Address Select Plug, Qty. 1
AMSU-A2	J5 RT Address Select Plug, Qty. 1

Location of the items to be added are shown in Figures 13 and 14. Each of the items will be tagged with a green tag stating "Add before flight."

4. THERMAL DESIGN

4.1 ***Temperature range***.- A combination of passive radiators and multi-layered insulation blankets on external surfaces maintain the operating temperature ranges of the AMSU-A instruments. Active heaters provide temperature control during the survival mode. Thermal isolators between the instrument and spacecraft limit the A1 interface heat transfer (in either direction) to 25 W/m^2 and the A2 interface heat transfer to 15 W/m^2.

Table I shows the temperature ranges for the critical AMSU components. Note the allowable temperature ranges for the A1 components in the operating condition.

Table I Temperature Range

Component	Where Temp. Reqt. Applies	Allow. Temp. Range (Min/Max, °C)	
	Reduced Model Node	Operating	Survival
A1-1 Warmload	49084	2 to +22	-20 to +50
A1-2 Warmload	49083	2 to +22	-20 to +50
A1-1 RF Shelf	49082	+12 to +32	-20 to +50
A1-2 RF Shelf	49081	+7 to +27	-20 to +50
A2 Warmload	50076	+10 to +30	-20 to +50
A2 RF Shelf	50085	+10 to +30	-20 to +50

4.2 ***Temperature sensor location***.- Temperature sensor locations for the A1 unit are described in Table II, and those for the A2 unit are described in Table III. General locations are shown in Figures 18 and 19.

4.3 ***Thermal control hardware***.- Survival heater power requirements are given in Section 5. Radiator requirements are described in Table IV. The interface between the instrument thermal control devices and the spacecraft thermal control devices is described in Aerojet Drawing TBD 6 for the A1 unit and Aerojet Drawing TBD 5 for the A2 unit. Locations of thermal control radiators and blankets on the surfaces of the A1 and A2 modules are shown in Figures 20 and 21, respectively.

Table II A1 Thermal Sensor Locations

Sensor Number	Sensor Location	Assembly Location
RT 1	A1-1 Scan Motor	A1-1 Antenna
RT 2	A1-2 Scan Motor	A1-2 Antenna
RT 3	Signal Processor	Signal Processor
RT 4	Radiator Panel	Thermal Control System
RT 5	A1-1 RF MUX	A1-1 RF Shelf
RT 6	A1-2 RF MUX	A1-2 RF Shelf
RT 7	DRO Channel 3	A1-2 RF Shelf
RT 8	DRO Channel 4	A1-2 RF Shelf
RT 9	DRO Channel 5	A1-2 RF Shelf
RT 10	DRO Channel 6	A1-1 RF Shelf
RT 11	DRO Channel 7	A1-1 RF Shelf
RT 12	DRO Channel 8	A1-2 RF Shelf
RT 13	DRO Channel 15	A1-1 RF Shelf
RT 14	P.L.O. #2 Channel 9/14	A1-1 RF Shelf
RT 15	P.L.O. #1 Channel 9/14	A1-1 RF Shelf
RT 16	Crystal Oscillator	A1-1 RF Shelf
RT 17	Mixer/IF CH-3	A1-2 RF Shelf
RT 18	Mixer/IF CH-4	A1-2 RF Shelf
RT 19	Mixer/IF CH-5	A1-2 RF Shelf
RT 20	Mixer/IF CH-6	A1-1 RF Shelf
RT 21	Mixer/IF CH-7	A1-1 RF Shelf
RT 22	Mixer/IF CH-8	A1-2 RF Shelf
RT 23	Mixer/IF CH-9/14	A1-1 RF Shelf
RT 24	Mixer/IF CH-15	A1-1 RF Shelf
RT 25	IF Amplifier CH 11/14	A1-1 RF Shelf
RT 26	IF Amplifier CH 9	A1-1 RF Shelf
RT 27	IF Amplifier CH 10	A1-1 RF Shelf
RT 28	IF Amplifier CH 11	A1-1 RF Shelf
RT 29	DC/DC Converter	Signal Processor
RT 30	IF Amplifier CH 13	A1-1 RF Shelf
RT 31	IF Amplifier CH 14	A1-1 RF Shelf
RT 32	IF Amplifier CH 12	A1-1 RF Shelf
RT 33	A1-1 RF Shelf	A1-1 RF Shelf
RT 34	A1-2 RF Shelf	A1-2 RF Shelf
RT 35	Detector/Preamp	Signal Processor
RT 36	A1-1 Warmload	A1-1 Warmload
RT 40		
RT 41	A1-2 Warmload	A1-2
RT 45		

Table III A2 Thermal Sensor Locations

Assigned Numbers	Description of Part Installed On	Assembly Used On
RT 1	Scan Motor	Antenna
RT 2	Signal Processor	Signal Processor
RT 3	Diplexer	RF Shelf
RT 4	Mixer/AMP IF CH. 1	RF Shelf
RT 5	Mixer/AMP IF CH. 2	RF Shelf
RT 6	Gunn Diode OSC CH. 1	RF Shelf
RT 7	Gunn Diode OSC CH. 2	RF Shelf
RT 8	Radiator Panel	Thermal Control System
RT 9	Secondary Reflector	Secondary Reflector
RT 10	DC/DC Converter	Signal Processor
RT 11	RF Shelf	RF Shelf
RT 12	Detector Preamp Assy	Signal Processor
RT 13	Warmload	Warmload
RT 19	TBD	TBD

Table IV Thermal Control Radiators

Radiator Location & Description	Surface Normal	Required Power. Dissipation (W)		Area (m^2)	Surface Material	Allowable Temperature Range (C°)		
		Operate Mode	Survival Mode			Operating	Safe	Survival
A1-upper side	+Y	78	36	TBD	SSM*	-30 to +50	-30 to +50	-30 to +50
A1-lower side	+Y	78	36	TBD	SSM*	-30 to +50	-30 to +50	-30 to +50
A1-upper rear	+X	78	36	TBD	SSM*	-30 to +50	-30 to +50	-30 to +50
A1-lower rear	+X	78	36	TBD	SSM*	-30 to +50	-30 to +50	-30 to +50
A1-top surface	+Z	78	36	TBD	SSM*	-30 to +50	-30 to +50	-30 to +50
A2-side radiator	-X	27	5	0.118	Silvered Teflon	-30 to +50	-30 to +50	-30 to +50
A2-side radiator	+X	27	5	0.106	Silvered Teflon	-30 to +50	-30 to +50	-30 to +50

* Second-surface mirrors

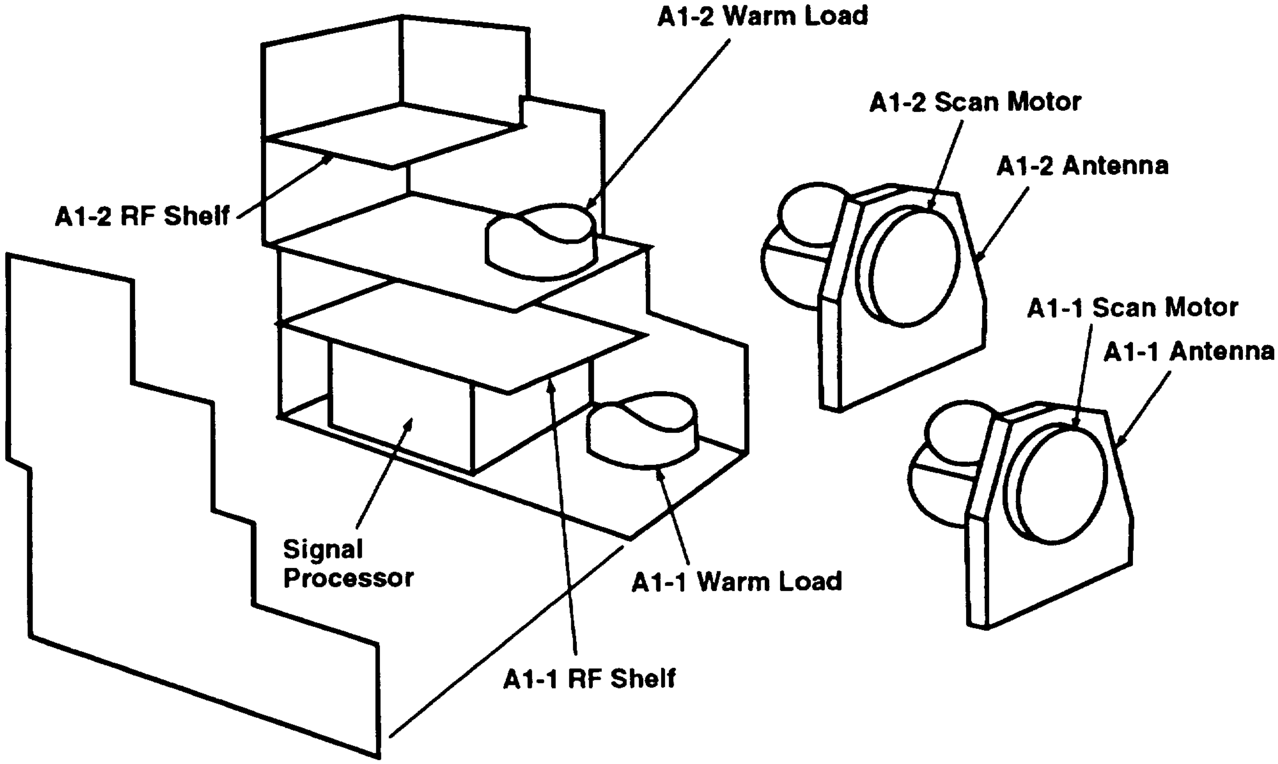


Figure 18 Exploded View of A1 Module Showing Major Locations

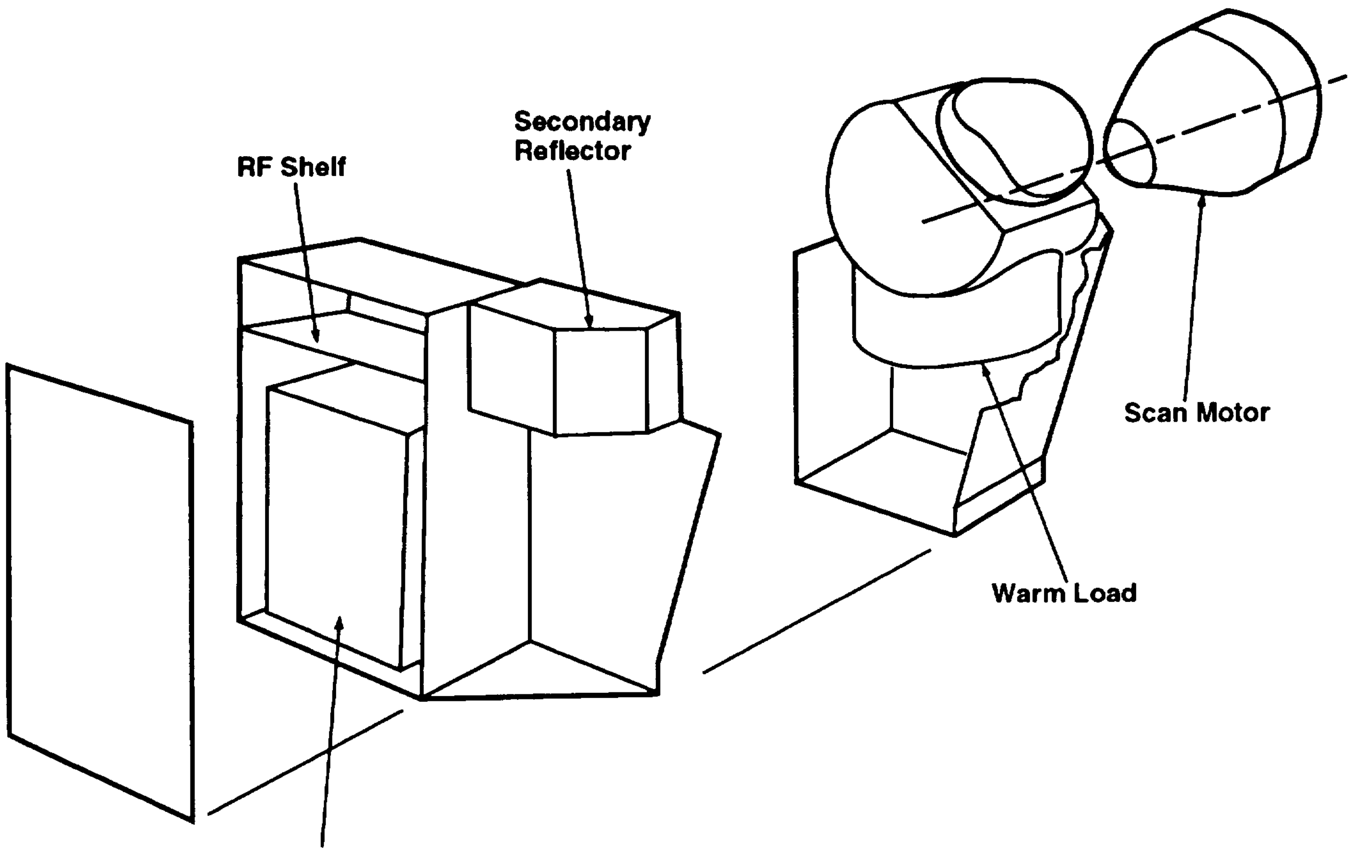


Figure 19 Exploded View of A2 Module Showing Major Locations

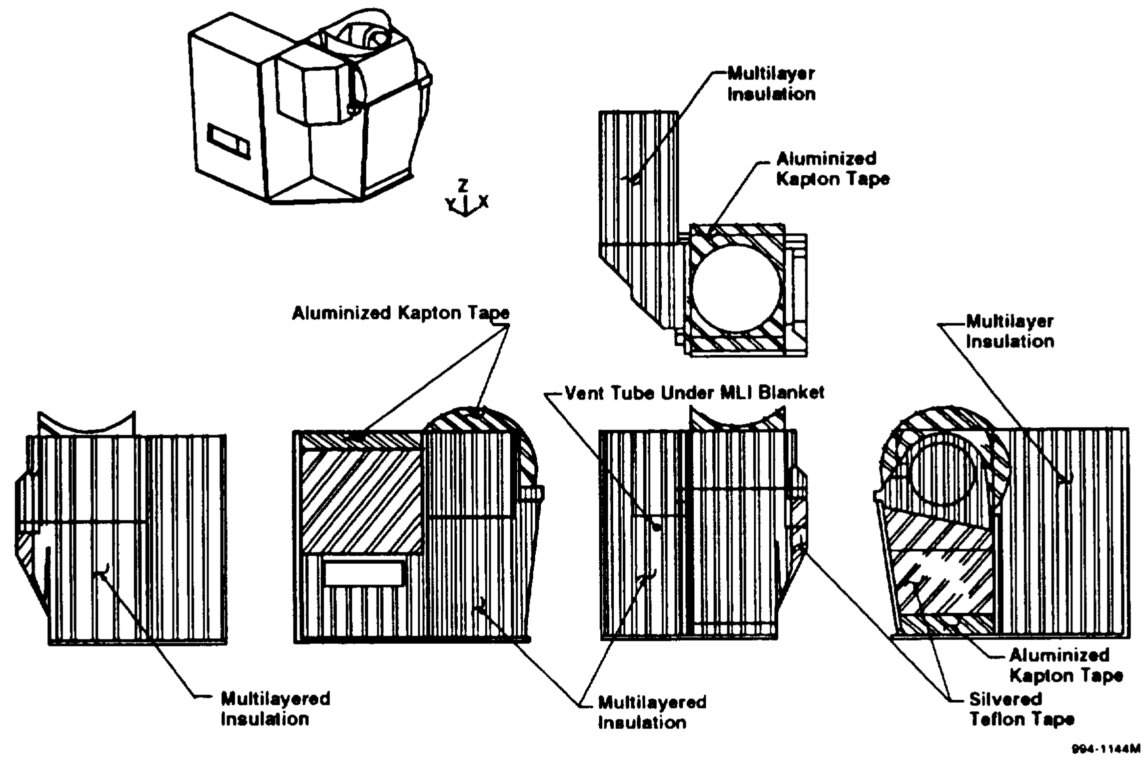


Figure 20 Locations of Thermal Radiators and Blankets on AMSU-A2

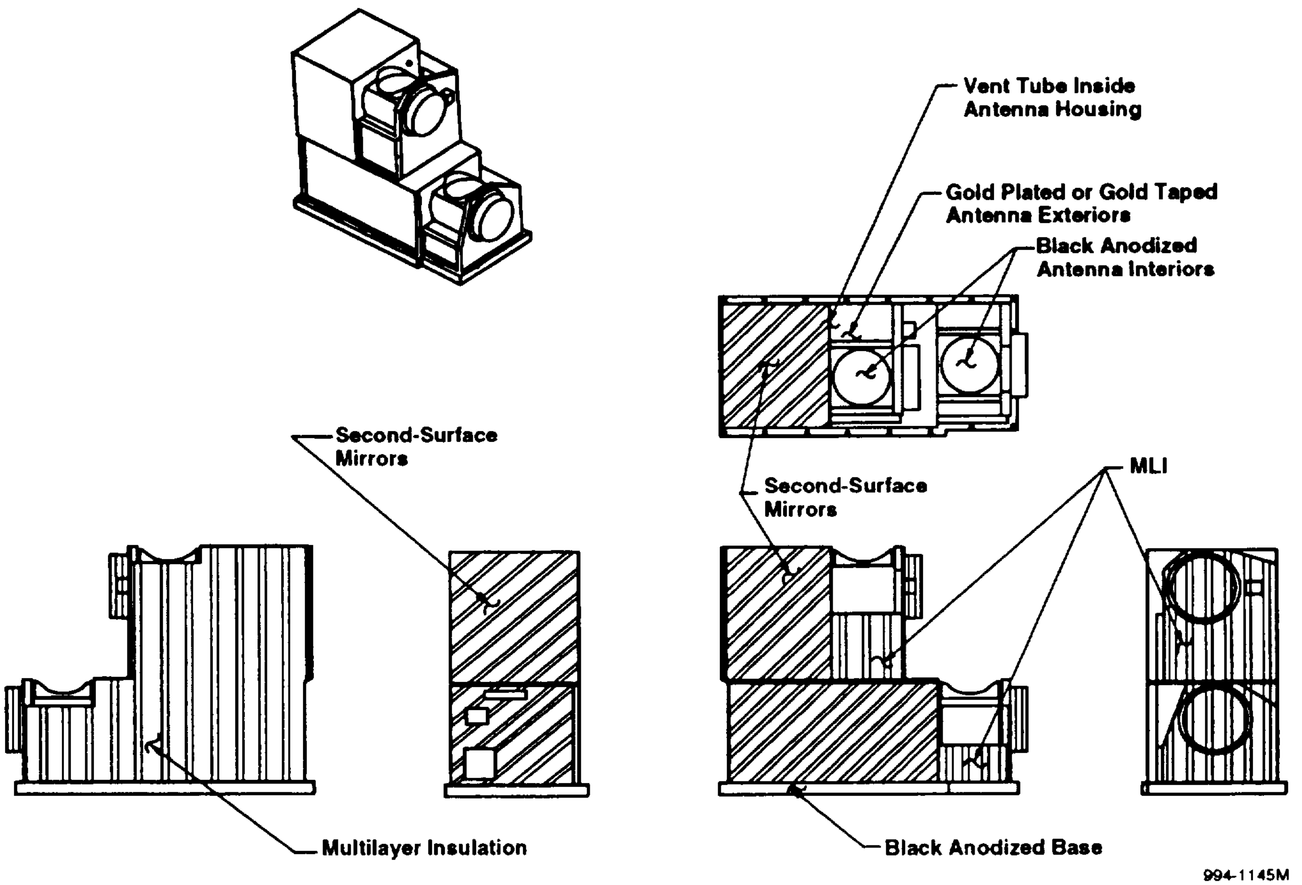


Figure 21 Locations of Thermal Radiators and Blankets on AMSU-A2

5. ELECTRICAL INTERFACE DESCRIPTION

5.1 ***Harnesses and connectors***.- The electrical interface to each of the AMSU instruments consists of three cables between each AMSU-A instrument and the spacecraft. Five connectors are provided for each instrument as described in Tables V and VI, but J4 is for test only, and J5 is for the MIL-STD-1553 RT address select.

5.1.1 ***Connector types and locations***.- The connector types are described in Table VII. Connector locations for the A1 unit are described in Figure 13. Connector locations for the A2 unit are described in Figure 14.

5.1.2 ***Wiring requirements***. Electrical Interface pinouts are described in Tables VIII through XVII.

5.1.3 ***Harness tie points***.- TBD

5.1.4 ***Flight plugs***.- The J4 and J5 connectors on each instrument will have captive flight plugs provided by the instrument supplier.

Table V A1 Wiring Harnesses

Cable	Connector	Type	Gender on Instrument	Use
Power	J1	25 D	male	Power inputs
Passive Analog	J2	37 D	male	Analog telemetry
I/O	J3	9 D	female	MIL-STD 1553 Interface
I/O	J4	37 D	female	GSE Test Interface Only
I/O	J5	9 D	male	RT Address Select Plug

Table VI A2 Wiring Harnesses

Cable	Connector	Type	Gender on Instrument	Use
Power	J1	25 D	male	Power inputs
Passive Analog	J2	37 D	male	Analog telemetry
I/O	J3	9 D	female	MIL-STD 1553 Interface
I/O	J4	37 D	female	GSE Test Interface Only
I/O	J5	9 D	male	RT Address Select Plug

Table VII EOS/AMSU Instrument Connectors

Instrument	Connector	GSFC PPL Part Number
A1	J1	TBD
	J2	TBD
	J3	TBD
	J4	TBD
	J5	TBD
A2	J1	TBD
	J2	TBD
	J3	TBD
	J4	TBD
	J5	TBD

5.2 *Grounding*

5.2.1 ***Grounding requirements***.- The power/grounding of the AMSU-A instrument is depicted in Figure 22. Both the A1 and A2 modules are identical.

5.2.2 ***Instrument tie points***.- The instrument signal reference will be (optionally) tied to instrument chassis ground and connected to pin 13 of the respective J1 connectors.

5.2.3 ***Spacecraft tie points***.- TBD

Table VIII Connector J1 of A1
[25 Pin, Male, D Connector (Power Bus)]

Pin	Description	Pin	Description
1	Quiet Power Bus "A"	14	Quiet Power Bus "B"
2	Quiet Power Bus "A" (redundant)	15	Quiet Power Bus "B" (redundant)
3	Quiet Power Bus "A" Return	16	Quiet Power Bus "B" Return
4	Quiet Power Bus "A" Return (redundant)	17	Quiet Power Bus "B" Return (redundant)
5	Noisy Power Bus "A"	18	Noisy Power Bus "B"
6	Noisy Power Bus "A" (redundant)	19	Noisy Power Bus "B" (redundant)
7	Noisy Power Bus "A" Return	20	Noisy Power Bus "B" Return
8	Noisy Power Bus "A" Return (redundant)	21	Noisy Power Bus "B" Return (redundant)
9	Survival Power Bus "A"	22	Survival Power Bus "B"
10	Survival Power Bus "A" Return	23	Survival Power Bus "B" Return
11	Survival Power Bus "A" (redundant)	24	Survival Power Bus "B" (redundant)
12	Survival Power Bus "A" Return (redundant)	25	Survival Power Bus "B" Return (redundant)
13	Instrument Chassis Ground		

Table IX Connector J2 of A1
[37 Pin, Male, D Connector (Passive Analog Telemetry)]

Pin	Description	Pin	Description
1	A1-1 Motor Primary PRT	20	A1-1 Motor Redundant PRT
2	A1-1 Motor Primary PRT Return	21	A1-1 Motor Redundant PRT Return
3	A1-1 Receiver Primary PRT	22	A1-1 Receiver Redundant PRT
4	A1-1 Receiver Primary PRT Return	23	A1-1 Receiver Redundant PRT Return
5	A1-1 Warm Load Primary PRT	24	A1-1 Warm Load Redundant PRT
6	A1-1 Warm Load Primary PRT Return	25	A1-1 Warm Load Redundant PRT Return
7	A1-2 Motor Primary PRT	26	A1-2 Motor Redundant PRT
8	A1-2 Motor Primary PRT Return	27	A1-2 Motor Redundant PRT Return
9	A1-2 Receiver Primary PRT	28	A1-2 Receiver Redundant PRT
10	A1-2 Receiver Primary PRT Return	29	A1-2 Receiver Redundant PRT Return
11	A1-2 Warm Load Primary PRT	30	A1-2 Warm Load Redundant PRT
12	A1-2 Warm Load Primary PRT Return	31	A1-2 Warm Load Redundant PRT Return
13	N/C	32	N/C
14	N/C	33	N/C
15	N/C	34	N/C
16	N/C	35	N/C
17	N/C	36	Noisy Bus Indicator Return
18	Quiet Bus Indicator Return	37	Noisy Bus Indicator
19	Quiet Bus Indicator		

Table X Connector J3 of A1
[9 Pin, Female, D Connector (1553 Data Busses)]

Pin	Description
1	Data Bus "A"
2	Data Bus "A" Return
3	N/C
4	Data Bus "B"
5	Data Bus "B" Return
6	Data Bus "A" Shield
7	N/C
8	N/C
9	Data Bus "B" Shield

Table XI Connector J4 of A1
[37 Pin, Female, D Connector (GSE Test Interface)]

Pin	Description	Pin	Description
1	Instrument Chassis Ground	20	N/C
2	N/C	21	N/C
3	Redundant PLLO Lock Detect	22	Primary P.L.O. Lock Detect
4	Redundant PLLO Lock Detect Return	23	N/C
5	I/H and Dump Return	24	I/H Signal
6	I/H and Dump	25	N/C
7	N/C	26	Analog Output Return
8	Channel 3 Analog Output Test Point	27	Channel 10 Analog Output Test Point
9	Channel 4 Analog Output Test Point	28	Channel 11 Analog Output Test Point
10	Channel 5 Analog Output Test Point	29	Channel 12 Analog Output Test Point
11	Channel 6 Analog Output Test Point	30	Channel 13 Analog Output Test Point
12	Channel 7 Analog Output Test Point	31	Channel 14 Analog Output Test Point
13	Channel 8 Analog Output Test Point	32	Channel 15 Analog Output Test Point
14	Channel 9 Analog Output Test Point	33	N/C
15	N/C	34	N/C
16	N/C	35	GSE CMD 3
17	GSE CMD 1	36	GSE CMD Return (+5V Return)
18	GSE CMD 2	37	N/C
19	N/C		

Table XII Connector J5 of A1
[9 Pin, Male, D Connector (RT Address)]

Pin	Description
1	TBD
2	TBD
3	TBD
4	TBD
5	TBD
6	TBD
7	TBD
8	TBD
9	TBD

Table XIII Connector J1 of A2
[25 Pin, Male, D Connector (Power Bus)]

Pin	Description	Pin	Description
1	Quiet Power Bus "A"	14	Quiet Power Bus "B"
2	Quiet Power Bus "A" (redundant)	15	Quiet Power Bus "B" (redundant)
3	Quiet Power Bus "A" Return	16	Quiet Power Bus "B" Return
4	Quiet Power Bus "A" Return (redundant)	17	Quiet Power Bus "B" Return (redundant)
5	Noisy Power Bus "A"	18	Noisy Power Bus "B"
6	Noisy Power Bus "A" (redundant)	19	Noisy Power Bus "B" (redundant)
7	Noisy Power Bus "A" Return	20	Noisy Power Bus "B" Return
8	Noisy Power Bus "A" Return (redundant)	21	Noisy Power Bus "B" Return (redundant)
9	Survival Power Bus "A"	22	Survival Power Bus "B"
10	Survival Power Bus "A" Return	23	Survival Power Bus "B" Return
11	Survival Power Bus "A" (redundant)	24	Survival Power Bus "B" (redundant)
12	Survival Power Bus "A" Return (redundant)	25	Survival Power Bus "B" Return (redundant)
13	Instrument Chassis Ground		

Table XIV Connector J2 of A2
[37 Pin, Male, D Connector (Passive Analog Telemetry)]

Pin	Description	Pin	Description
1	A2 Motor Primary PRT	20	A2 Motor Redundant PRT
2	A2 Motor Primary PRT Return	21	A2 Motor Redundant PRT Return
3	A2 Receiver Primary PRT	22	A2 Receiver Redundant PRT
4	A2 Receiver Primary PRT Return	23	A2 Receiver Redundant PRT Return
5	A2 Warm Load Primary PRT	24	A2 Warm Load Redundant PRT
6	A2 Warm Load Primary PRT Return	25	A2 Warm Load Redundant PRT Return
7	N/C	26	N/C
8	N/C	27	N/C
9	N/C	28	N/C
10	N/C	29	N/C
11	N/C	30	N/C
12	N/C	31	N/C
13	N/C	32	N/C
14	N/C	33	N/C
15	N/C	34	N/C
16	N/C	35	N/C
17	N/C	36	Noisy Bus Indicator Return
18	Quiet Bus Indicator Return	37	Noisy Bus Indicator
19	Quiet Bus Indicator		

Table XV Connector J3 of A2 [9 Pin, Female, D Connector (1553 Data Busses)]

Pin	Description
1	Data Bus "A"
2	Data Bus "A" Return
3	N/C
4	Data Bus "B"
5	Data Bus "B" Return
6	Data Bus "A" Shield
7	N/C
8	N/C
9	Data Bus "B" Shield

Table XVI Connector J4 of A2 [37 Pin, Female, D Connector (GSE Test Interface)]

Pin	Description	Pin	Description
1	Instrument Chassis Ground	20	N/C
2	N/C	21	N/C
3	N/C	22	N/C
4	N/C	23	I/H Signal Test Point
5	I/H and Dump Return	24	N/C
6	I/H and Dump Signal	25	N/C
7	N/C	26	Instrument Signal Reference Return
8	Channel 1 Analog Output Test Point	27	N/C
9	Channel 2 Analog Output Test Point	28	N/C
10	N/C	29	N/C
11	N/C	30	N/C
12	N/C	31	N/C
13	N/C	32	N/C
14	N/C	33	N/C
15	N/C	34	N/C
16	N/C	35	GSE CMD MSB
17	GSE CMD LSB	36	GSE CMD Return (=5Y Return)
18	GSE CMD MSB-1	37	N/C
19	N/C		

Table XVII Connector J5 of A2 [9 Pin, Male, D Connector (RT Address)]

Pin	Description
1	TBD
2	TBD
3	TBD
4	TBD
5	TBD
6	TBD
7	TBD
8	TBD
9	TBD

5.3 *Power interface*

5.3.1 ***Power requirements.***- The power budgets for the A1 and A2 units are presented in Table XVIII.

Table XVIII Power Requirements (watts)

Module	Noisy Power Bus		Quiet Power Bus		Survival Power Bus	
	Budget	Nominal	Budget	Nominal	Budget	Nominal
A1	4.0	3.1	79.0	74.3	36.0	0
A2	4.0	3.2	28.0	23.6	5.0	0

5.3.2 ***Overcurrent protection.***- Spacecraft overcurrent protection of the instruments shall be sized to accommodate the loads specified in Table XIX.

Table XIX Loads (amps)

Bus	A1	A2
Noisy Bus	0.28 Avg 1.0 Peak	0.18 Avg 1.0 Peak
Quiet Bus	3.0	1.0
Survival Bus	1.6	0.22

5.3.3 ***High voltage restrictions.***- TBD

5.4 ***Digital interface.***- The digital interface is conducted over the respective J3 connectors using dual standby redundant MIL-STD-1553 data buses. Each instrument will be assigned a unique Remote Terminal (RT) address by the spacecraft provider which will be encoded on the captive flight plugs of the respective J5 connectors by the instrument provider.

5.5 ***Analog interface.***- The analog interface is conducted over the respective J2 connectors. The spacecraft analog interface shall be designed to sense an instrument transducer resistance in the range of zero to five kilohms using an 8-bit analog-to-digital converter. The instrument transducer circuitry shall be required to sink up to 1 milliampere (mA) of current. Load capacitance of the transducer circuitry measured at the J2 connector shall be less than 1800 picofarads (pF).

5.6 ***Test interface.***- Three potential test conditions exist at the spacecraft contractor's facility, Pre-Installation Tests, Integrated Observatory/AMSU-A Tests, and Trouble-Shooting Tests. The interconnects for the Pre-Installation Tests or Trouble Shooting Tests are depicted in Figure 22, showing the instrument, the break-out box (BOB), and the instrument GSE. Figure 23 depicts the interconnects for the Integrated Observatory/ AMSU-A Test, showing the GSE operating as a receive-only workstation connected to the Observatory GSE through an ETHERNET. Figure 24 depicts the interconnect for Trouble Shooting Tests, which requires access to the instrument.

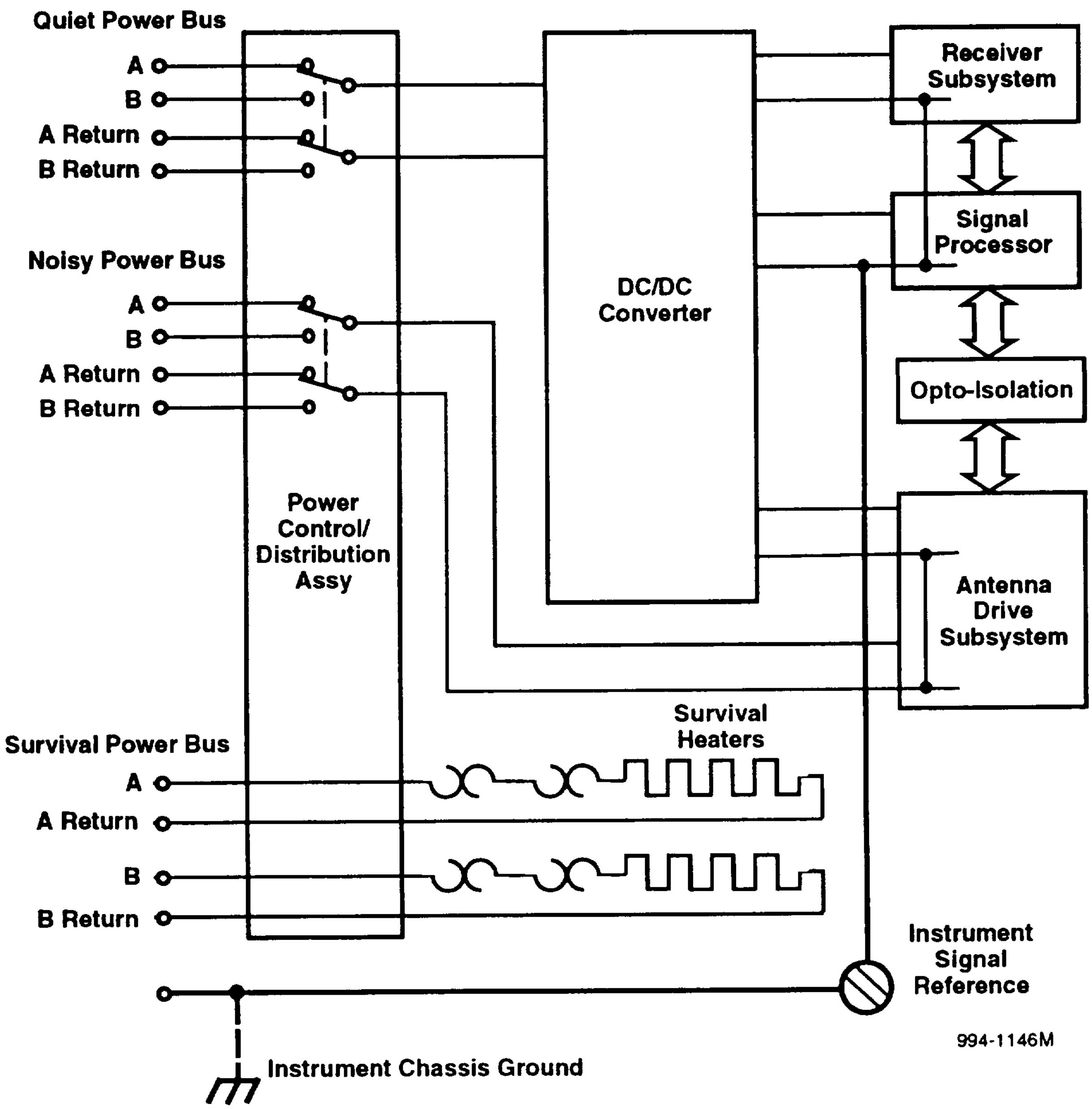


Figure 22 EOS/AMSU-A Power/Grounding Interface (A1 Or A2)

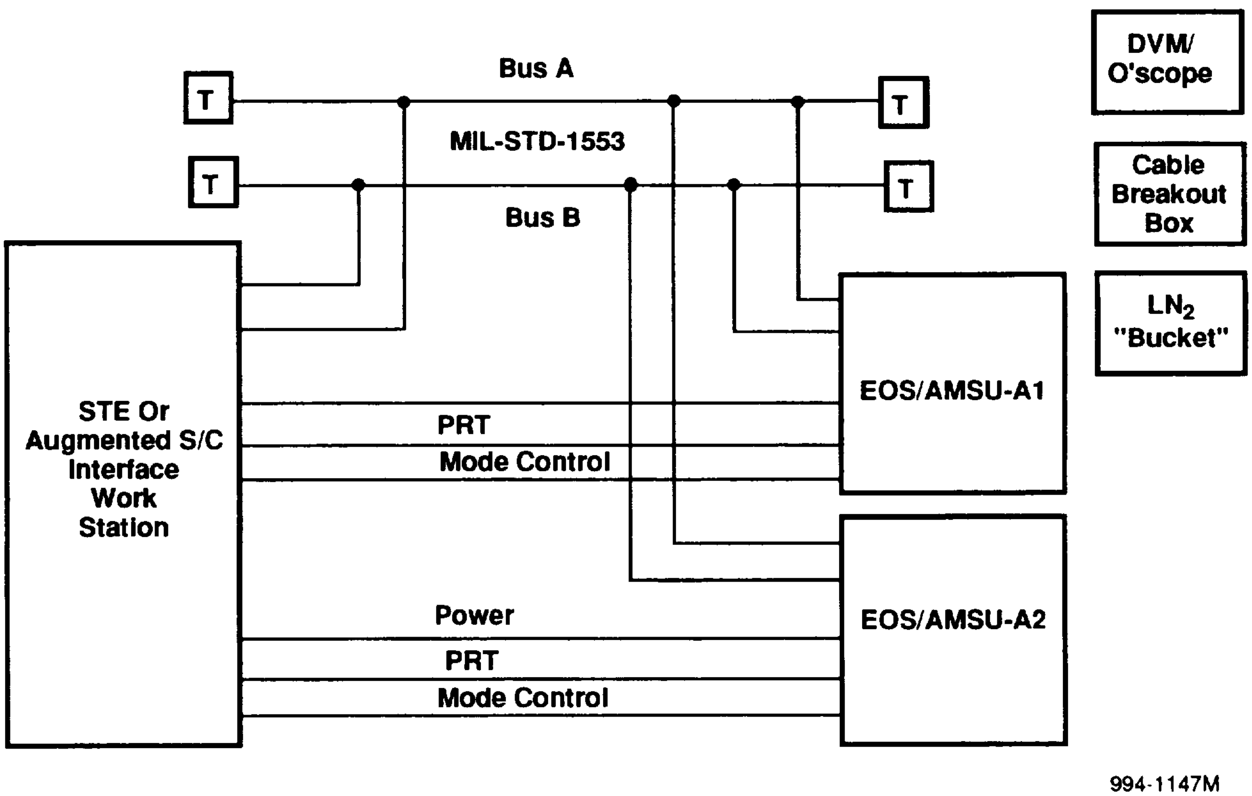


Figure 23 Pre-Installation or Troubleshooting Tests

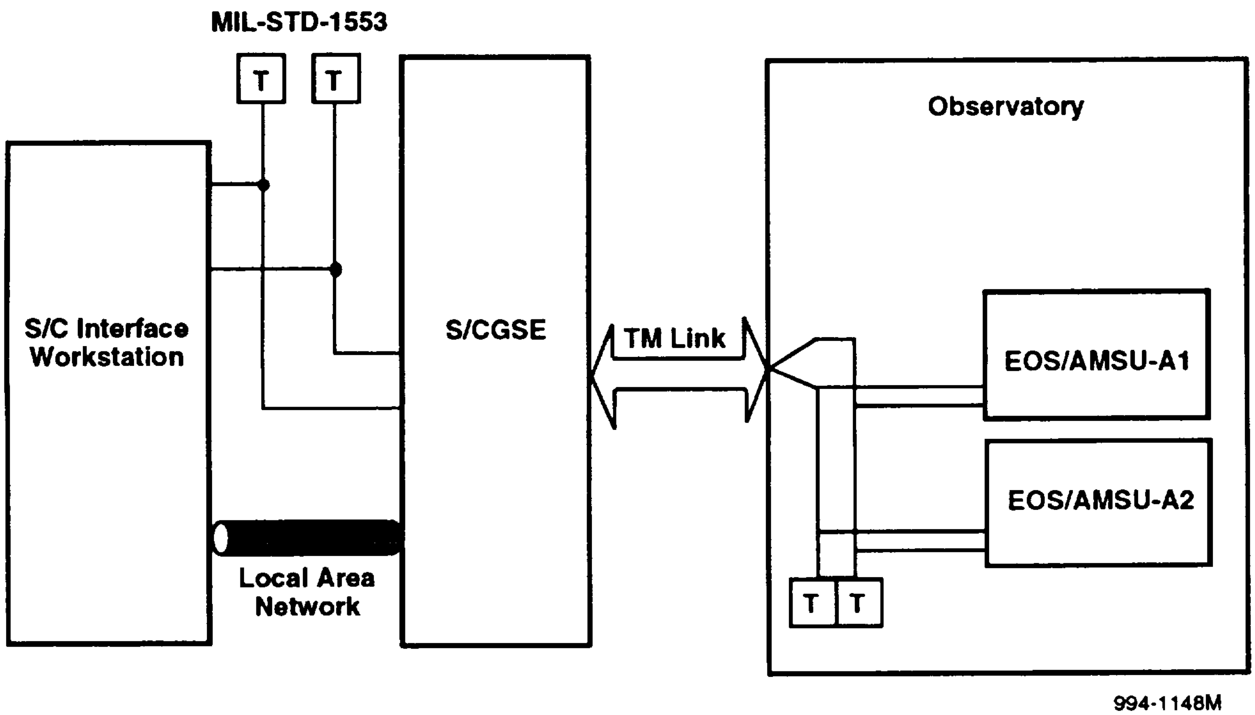


Figure 24 Integrated Observatory/AMSU-A Tests

6. COMMAND AND DATA HANDLING DESCRIPTION

6.1 ***Instrument modes.***- The AMSU-A operational modes are described in Table XX.

Table XX AMSU-A Operational Modes

AMSU-A Mode* Name	Description
OFF	Power OFF. Reflectors parked facing warm loads, A1 module PLO relay at "Primary", scan drive power relays in "OFF" positions.
SURVIVAL	Power OFF. Reflectors facing warm loads, survival heaters enabled by spacecraft and thermostatically controlled by instrument. Spacecraft monitoring passive analog temperature sensors in instrument.
ACTIVATION	Power ON to Receiver and Signal Processor Subsystems. Command and Data Handling interface in operation. Power OFF to all scan drive motors and reflectors parked facing warm loads.
OPERATIONAL	Power ON to all subsystems and reflectors scanning normally.
SAFE	Power ON to all subsystems and reflectors parked facing warm loads.
* This table defines the AMSU-A operating modes. Operational modes do not stipulate which redundancy is used in the case of redundant subsystems.	

6.2 ***Instrument reconfiguration commands.***- The instrument is not reprogrammable.

6.3 ***Passive analog telemetry.***- The A1 instrument contains 14 passive analog telemetry temperature circuits and two bus selector status circuits interfacing through its J2 connector. The A2 instrument contains 8 passive analog telemetry temperature circuits and two bus selector status circuits interfacing through its J2 connector. Passive analog telemetry shall be under the control of the spacecraft command and data handling system. Settling time between switching to a particular analog telemetry transducer circuit and sampling at the analog-to-digital (ADC) shall be no less than 50 microseconds.

6.4 ***General command and data handling requirements***

6.4.1 ***Instrument RT address assignment.***- The spacecraft supplier shall assign the Remote Terminal (RT) address, 0 to 31, for each unit. The instrument supplier will configure the instrument for the assigned address.

6.4.2 ***Application Process Identification.***- TBD

6.4.3 ***Instrument commands.***- There are no critical commands that could damage the instrument in any situation. Power switching commands are described in Table XXI. Operational commands are identical for the A1 and A2 units. These are described in Table XXII. The operational commands are effective when the appropriate control bits are high. If more than one command is applied simultaneously, the priority is as follows: Full scan, warm calibration, cold calibration, NADIR. The GSE test scenario commands are described in Table XXIII. These commands are used exclusively for ground test and calibration purposes. They are disabled before flight by attaching the captive flight plug on the respective J4 connectors, which grounds the appropriate control wires and interrupts the enabling voltage source. The instrument must be placed into the operational **No Mode** state before the test scenarios can be enabled. Bit patterns for each command are TBD.

Table XXI Power Switching Commands

Command	Effect
A1-1 SCAN ON/OFF	Applies or removes 28 volt power from the Noisy Power Bus to the A1-1 scan drive output circuits thus controlling reflector scan operation. If command bit is zero, power is OFF. If column bit is one, power is ON.
A1-2 SCAN ON/OFF	Applies or removes 28 volt power from the Noisy Power Bus to the A1-2 scan drive output circuits thus controlling reflector scan operation. If command bit is zero, power is OFF. If command bit is one, power is ON.
A2 SCAN ON/OFF	Applies or removes 28 volt power from the Noisy Power Bus to the A2 scan drive output circuits thus controlling reflector scan operation. If command bit is zero, power is OFF. If command bit is one, power is ON.
A1 PLO PRIMARY/REDUNDANT	Energizes primary or redundant Phased Lock Loop Oscillator in the A1 instrument module. If command bit is zero, redundant PLO is selected. If command bit is one, primary PLO. is selected.

Table XXII Operational Commands

Command	Effect
REFLECTOR TO WARM CALIBRATION	Commands the instrument reflectors to move to the warm calibration position and stop there.
REFLECTOR TO NADIR POSITION	Commands the instrument reflectors to move to the Nadir position (between scene stations 15 and 16) and stop there.
REFLECTOR TO COLD CALIBRATION	Commands the instrument reflectors to move to the cold calibration position selected by the Cold Calibration Position select command (q.v.) and stop there. There are four cold calibration positions.
COLD CALIBRATION POSITION 1 SELECT	Selects cold calibration position 1 (-96.667° relative to zenith).
COLD CALIBRATION POSITION 2 SELECT	Selects cold calibration position 2 (-98.333° relative to zenith).
COLD CALIBRATION POSITION 3 SELECT	Selects cold calibration position 3 (-99.999° relative to zenith).
COLD CALIBRATION POSITION 4 SELECT	Selects cold calibration position 4 (-103.332° relative to zenith).
FULL SCAN ON/OFF	Full scan on commands instrument into the normal operation scanning mode. When full scan OFF is commanded and no other command is given reflectors will complete scanning cycle and park at warm load.
NO MODE	A state that exists when none of the above commands has been issued to the instrument. The instrument must be in this mode for the GSE scenarios (q.v.) to be invoked during ground test.
SAFE	A command macro that, in sequence, parks the reflectors in the warm load positions, selects the primary PLO, and removes the 28 volt noisy bus power from the scan drive circuits. This is the preferred instrument shut down command.

Table XXIII GSE Scenarios

GSE Scenario No.	Description
1	The reflectors slew directly to scene station 6, then cold calibration, then warm calibration, pausing at each. The action is repeated until the command is revoked.
2	The reflectors slew directly to scene station 1, moving in either direction of rotation, depending on which provides the shortest path. The reflectors remain at scene station 1 until commanded elsewhere.
3	The reflectors step through all thirty scene stations plus the two calibration positions, remaining at each for 8 seconds. The instrument will repeat this cycle until the command is revoked.
4	The reflectors slew directly to scene station 30, moving in either direction of rotation, depending on which provides the shortest path. The reflectors remain at scene station 30 until commanded elsewhere.
5	The reflectors slew directly to scene station 6, moving in either direction of rotation, depending on which provides the shortest path. The reflectors remain at scene station 6 until commanded elsewhere.
7	This is used in conjunction with GSE Scenario 3 and will pause the reflectors at whatever position they happen to be in.
0	This command disables the GSE scenario mode and allows the instrument to return to normal operation.

6.5 ***Critical engineering data for safe mode.***- The critical engineering data shall consist of instrument mode, relay status, all secondary voltages, and power bus currents.

6.5.1 ***Sampling rates.***- Peak and average data rate for the A1 instrument shall not exceed 2.1 kilobits per second (Kbps) and 1.1 Kbps for the A2 instrument for a total of 3.2 Kbps. Time delay between SYNC WITH DATA command and start of sampling integration is TBD. Start of scan begins after time code of (III).

7. CONTAMINATION

7.1 ***Cleanliness requirements***.- The instrument will be delivered to the spacecraft contractor's facility at a surface cleanliness level compliant with MIL-STD-1246 Level 600A. A class 10,000 work area is required during integration and test at the spacecraft provider's facility. The temperature requirements are 24° ± 6°C, with a relative humidity from 25 percent to 60 percent. Thermal radiators on the A1 and A2 instrument are contamination sensitive. No more than 500 Angstroms of contamination is allowable at end of mission life for the A1 unit thermal radiators and no more than 400 angstroms for the A2 unit thermal radiators.

7.2 ***Instrument sources of contamination***.- The instrument scan drive motor bearings are lubricated with Apiezon C, a high outgassing lubricant. Analysis predicts that small amounts of lubricant will escape the bearings in vacuum and may be deposited on nearby surfaces. The A2 unit bearings should release about four times as much lubricant as the A1 bearings. The deposition is strongly dependent on the spacing between instruments. The worst-case expected contamination of neighboring surfaces by the A2 bearing lubricant is depicted in Figure 25. Contamination-sensitive instrument surfaces of other instruments aboard the spacecraft must be maintained at least 30 cm away from the A2 motor axes, and must not have unobstructed line of sight to any axis.

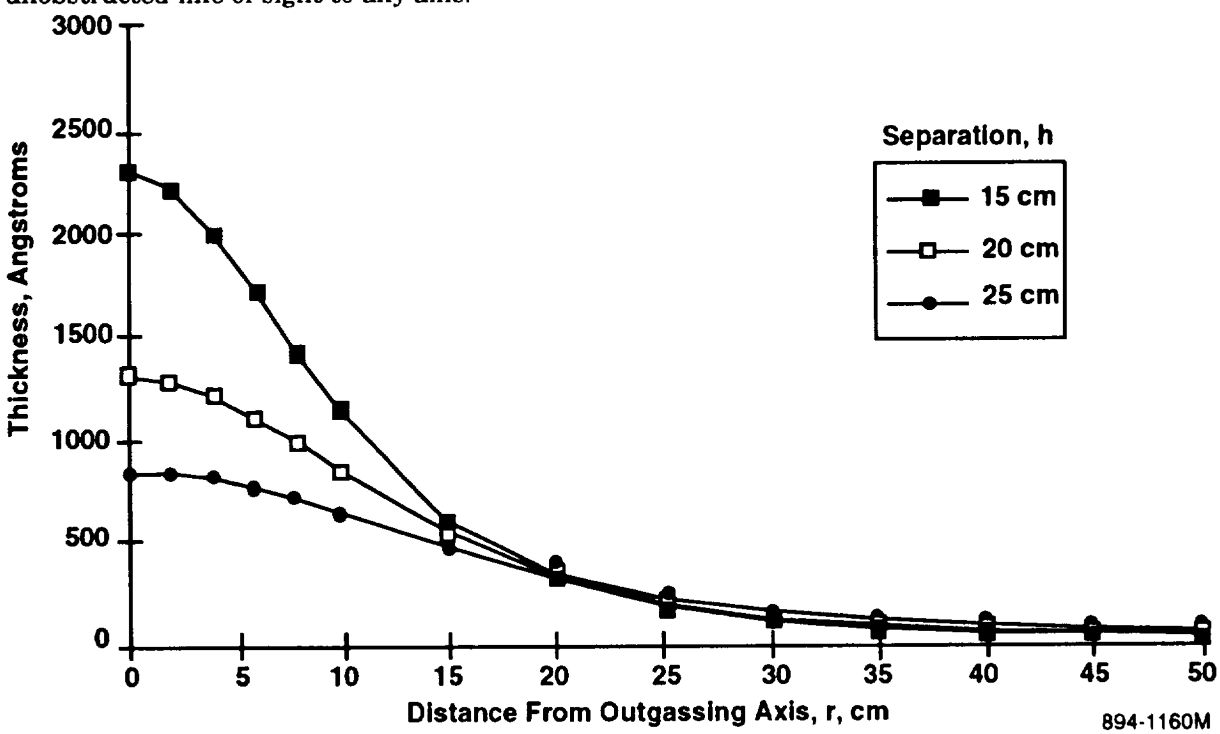


Figure 25 Deposition From A2 Bearings

7.3 ***Instrument venting***.- The vent location of the A1 instrument is shown in Figure 26. The vent location of the A2 instrument is shown in Figure 27.

7.4 ***Cover requirements***.- Covering and bagging material used for contamination protection must also provide electrostatic discharge (ESD) protection. Non-flight covers are provided by the instrument provider and must be maintained over the feedhorns, the rotating portions of the instruments, and the antenna apertures during integration and removed before flight. The IAC covers will be installed prior to flight

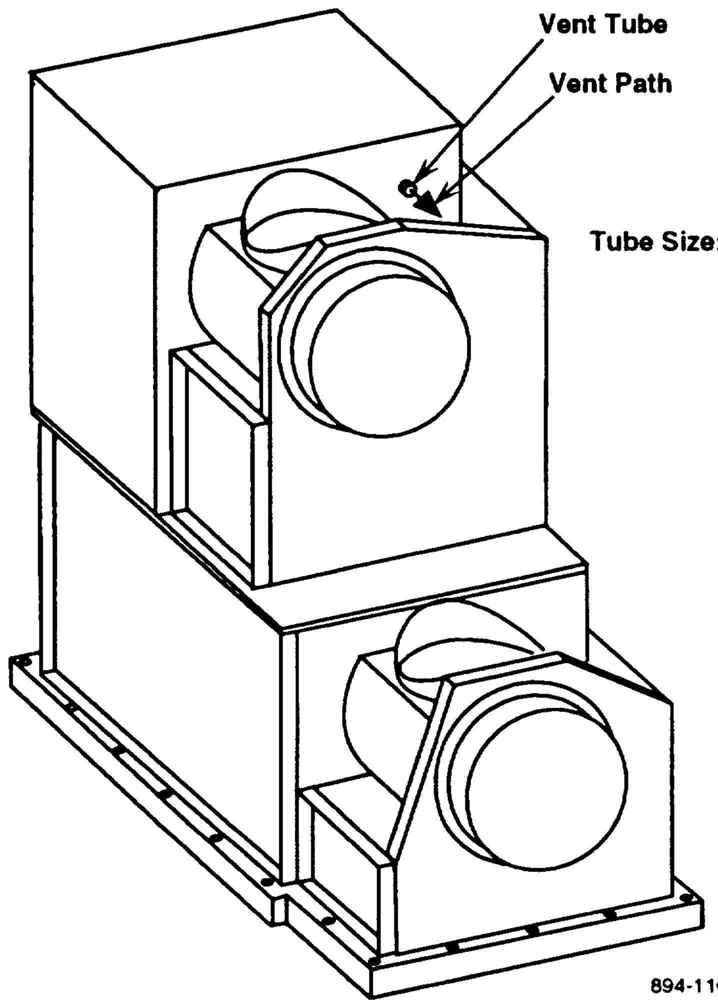


Figure 26 AMSU-A1 Vent Path

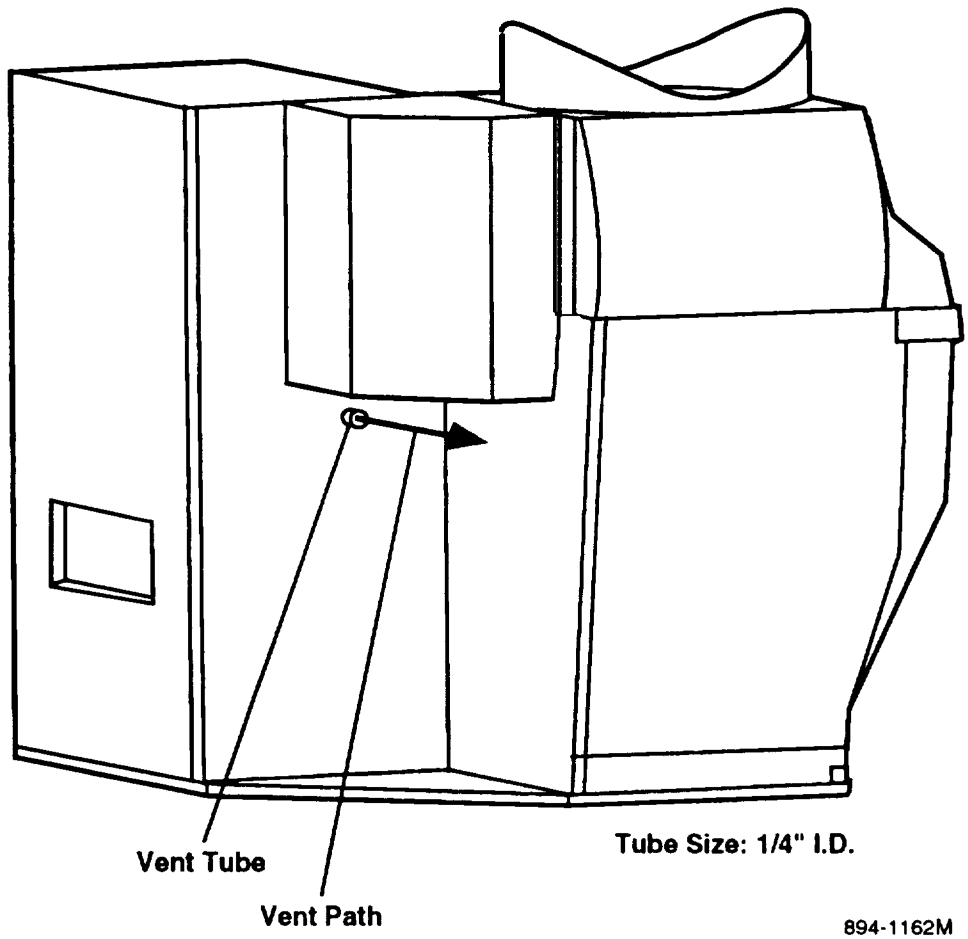


Figure 27 AMSU-A2 Vent Path

7.5 ***Purge requirements.***- A dry nitrogen purge, to be provided with the instrument, and conforming to the requirements of MIL-P-27401, Type I, Grade B or better, must be maintained on the scan motor bearings any time the instrument is outside a Class 10,000 cleanroom area. Once mounted to the spacecraft, the instruments rely upon the protective covers for contamination protection.

7.6 ***Inspection and cleaning requirements.***- TBD.

8. ENVIRONMENTS

8.1 ***Instrument magnetic fields***.- TBD.

9. MODEL REQUIREMENTS

9.1 *Surface model requirements*

9.1.1 ***Coordinate system***.- Figures 28 and 29 show the Central Coordinate System (CCS) of the Thermal Radiation Analyzer System (TRASYS) surface models. In accordance with the requirements of the GIRD, the CCS are parallel to the Spacecraft Reference Coordinate Frame. The A1 CCS is displaced from the corner of the model by 0.5 inch in the minus X direction, and 1.06 inches in the Z direction. The A2 CCS is at the corner of the model.

9.1.2 **TRASYS** ***model identification numbers***.- Node numbers 49000-49999 were assigned to AMSU-A1 and numbers 50000-50999 were assigned to AMSU-A2. Figures 28 and 29 show many of the nodes.

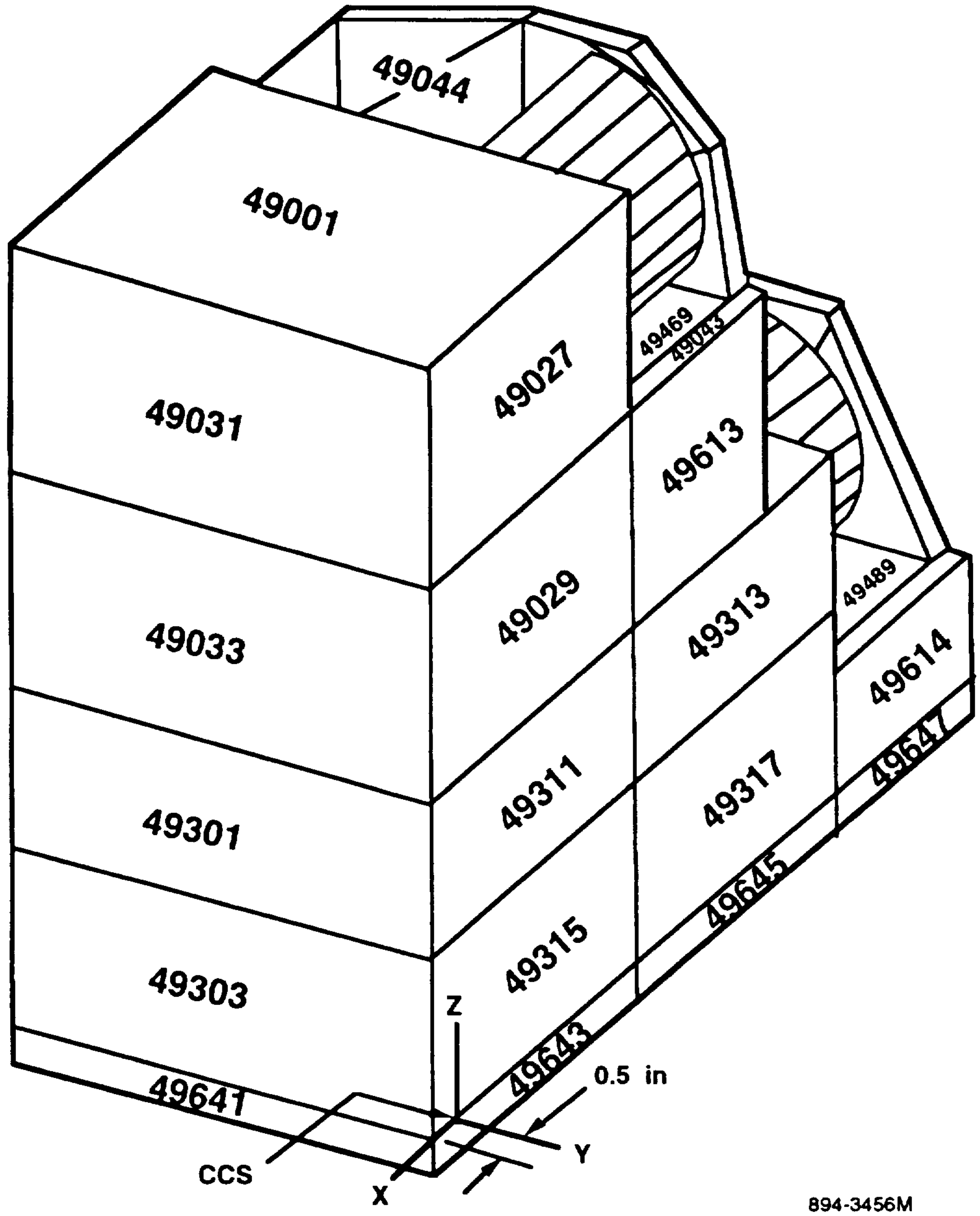


Figure 28 A1 TRASYS Surface Model

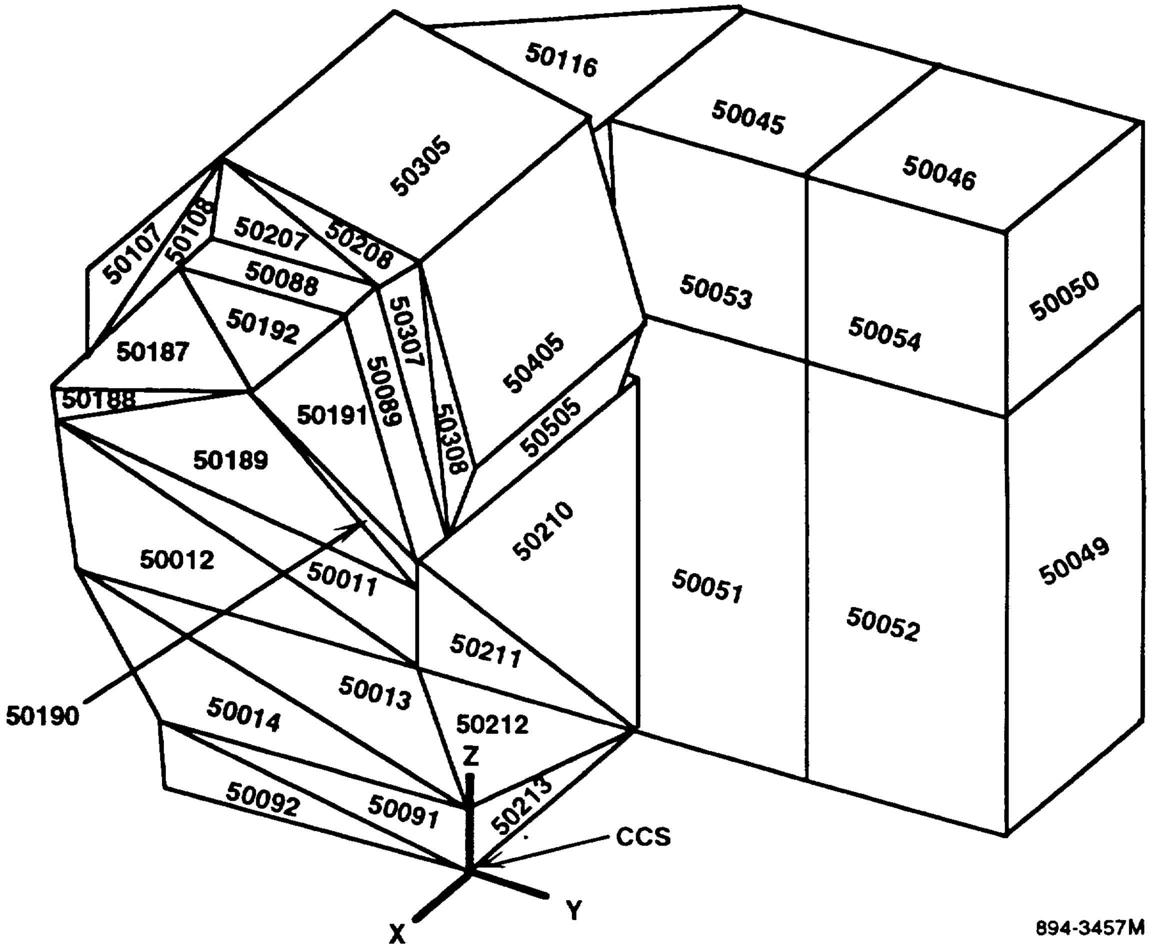


Figure 29 A2 TRASYS Surface Model

10. NOTES

10.1 ***Pointing accuracy calculation conventions***.- This paragraph is for clarification only. Accuracy and knowledge are expressed as zero-to-peak variations. Stability is expressed as a peak-to-peak variation. The spacecraft allocation for accuracy and knowledge is root-sum-squared with the instrument allocation to provide the total instrument accuracy and knowledge allocation. Post-processed spacecraft orbit determination errors present in the level 1 data from EOSDIS are included in the spacecraft allocation. The spacecraft allocation for stability is arithmetically added to the instrument allocation for stability to provide the total instrument stability allocation. Short term jitter attributed to the settling time of the antenna after each step is excluded from the above allocations.

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This Interface Control Document (ICD) defines the specific details of the complete accommodation information between the Earth Observing System (EOS) PM Spacecraft and the Advanced Microwave Sounding Unit (AMSU-A) Instrument. This is the first submittal of the ICD; it will be updated periodically throughout the life of the program. The next update is planned prior to Critical Design Review (CDR).

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