Report 10357
Final
20 November 1994

Earth Observing System (EOS)
Advanced Microwave Sounding Unit-A (AMSU-A)
Worst-Case Analysis - Antenna Beam Pointing

Contract No: NAS 5-32314
CDRL: 112B

Submitted to:

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

Submitted by:

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INTRODUCTION

This report is provided in partial fulfillment of the requirement for worst-case analyses of the Advanced Microwave Sounding Unit-A to be flown on the Earth Observing System (EOS/AMSU-A). It is submitted in response to Contract NAS5-32314, CDRL Item 112.

Presented is a worst-case analysis of the EOS/AMSU-A Beam Pointing. Two worst-case analyses addressing an in-orbit calibration accuracy analysis and an in-orbit radiometer sensitivity (NEΔT) analysis were provided under a separate cover (Aerojet Report No. 10471).

WORST-CASE ANALYSIS -

ANTENNA BEAM POINTING FOR EOS/AMSU-A

Requirement

The EOS/AMSU-A beam pointing requirements are given in GSFC-422-12-12-01, Performance and Operation Specification for the Advanced Microwave Sounding Unit-A. The specification states that for each beam position, in both the scan (cross-track) and the spacecraft velocity (down-track) directions, the beam pointing accuracy for each beam shall be better than ±0.2°.

Analysis

There are three sources of beam pointing error. These are mechanical tolerances in the manufacture and assembly of the parts, allowable axial displacement of the reflector relative to the motor shaft, and on-orbit thermal distortions. For the worst-case analysis, each will be assumed to act independently and thus each contribution is additive.

The mechanical tolerance analysis was completed using the NOAA/AMSU-A drawings as references. For the A2 module, the NOAA/AMSU-A drawing details relating to beam pointing will remain unchanged for the EOS/AMSU-A configuration. For the A1 module, the spacecraft mounting surface will be changed from the NOAA/AMSU-A side-mounted system to the EOS/AMSU-A base mount. However, the mechanical assembly and machining steps are expected to be similar to those used for the NOAA/AMSU-A1 module. Detailed calculations for the mechanical errors are shown in Figures 1 and 2 for the A1 and A2 modules, respectively.

The key to controlling the mechanical tolerances to acceptable beam pointing limits is in the assembly sequence of the structure. The primary structures of both modules are assembled to a level termed the machined antenna subassembly. For the NOAA/AMSU-A configurations, the A1 subassembly is detailed on Drawing 1331351, while the corresponding A2 subassembly is described on Drawing 1331303. The structural parts that will be removed at higher levels of assembly are match-drilled and pinned to the subassembly. The interfaces most affecting alignment are machined on the subassembly. These are the spacecraft mounting interface, the motor drive mounting interfaces, and the alignment cube interface. In this manner, the tolerance build-ups of the individual parts are eliminated at the subassembly.

The sources of error will be explained in the order of presentation in Table I. The first three errors are associated with the alignment cube. The first is the error in the surface (wave) of the alignment cube optical surface. The second is the error in locating the optical surface relative to the cube mounting surface. This error is attributable to the fabrication of the cube. The third error is the result of the machining accuracy of the cube mounting surface on the machined antenna subassembly.

The motor mount error is the machining error in establishing the motor mount surface on the machined antenna subassembly. As shown in Figure 1, the error was calculated for both the upper motor mount and the lower motor mount. The worst case from these calculations was entered in Table I. The motor shaft error is the allowable shaft run-out error relative to the motor mounting surface. At this assembly, the motor bearings and shaft are installed in the housing, and the mounting surface of the housing is machined relative to the shaft.

The reflector tolerance refers to the location of the parabolic surface of the antenna relative to the hub that interfaces with the motor shaft. The locating pin position refers to the dowel pin positions on the interface. Each module has two dowel pins for locating the instrument. For NOAA/AMSU-A, the A1 pin positions add to the down-track error. For the EOS/AMSU-A configurations the locating pin errors for both the A1 and A2 modules contribute to the cross-track pointing error. The final mechanical tolerance is the accuracy of machining the spacecraft interface relative to the cube surface and the motor mounting surfaces. The error is controlled at the machined subassembly level.

Relative axial movement of the antenna along the motor shaft will cause the illumination distribution of the reflector relative to the feedhorn to change. This has a minimum effect on the down-track beam pointing error, and no measurable effect on cross-track beam pointing error. The down-track error functions are shown in Figures 3 and 4 for the A1 and A2 modules, respectively. The allowable movement of the antenna along the motor shaft is 0.015 inch. This is verified by measurements taken before and after structural tests. The worst-case beam shift at ± 0.015 inch was entered in Table I.

The final contribution to beam pointing error results from thermal distortions that may occur on orbit. Since detailed thermal analyses cannot be undertaken until the EOS spacecraft is defined, the thermal distortion has only been budgeted at this time. The beam-pointing error is based on an assumed 10°C thermal gradient from the mounting surface to the motor drive mounting surface. The effect of the gradient is estimated by assuming that the structure at the height of the motor mounting surface is stationary and that the aluminum mounting surface changes by 10°C. The thermal distortion at the base divided by the distance to the motor mounting surface gives the slope of the beam pointing error.

Summary

As shown in Table I, the worst-case beam-pointing errors for both the A1 and A2 modules are less than the required 0.2 degree.

Table I Worst-Case Beam-pointing Error

Source of Error	Error in Degrees	
	A1	A2
Cube Surface Finish	0.005	0.005
Cube Perpendicularity	0.022	0.022
Cube Mounting Accuracy	0.044	0.044
Motor Mount Tolerance	0.008	0.006
Motor Shaft Tolerance	0.010	0.044
Reflector Tolerance	0.030	0.029
Locating Pin Position	0.025	0.017
Interface Tolerance	0.024	0.005
Mechanical Tolerance	0.168	0.173
Reflector/Shaft Slip	0.009	0.017
Thermal Distortion (10°C)	0.017	0.006
WORST CASE	0.194	0.196
RSS	0.071	0.077

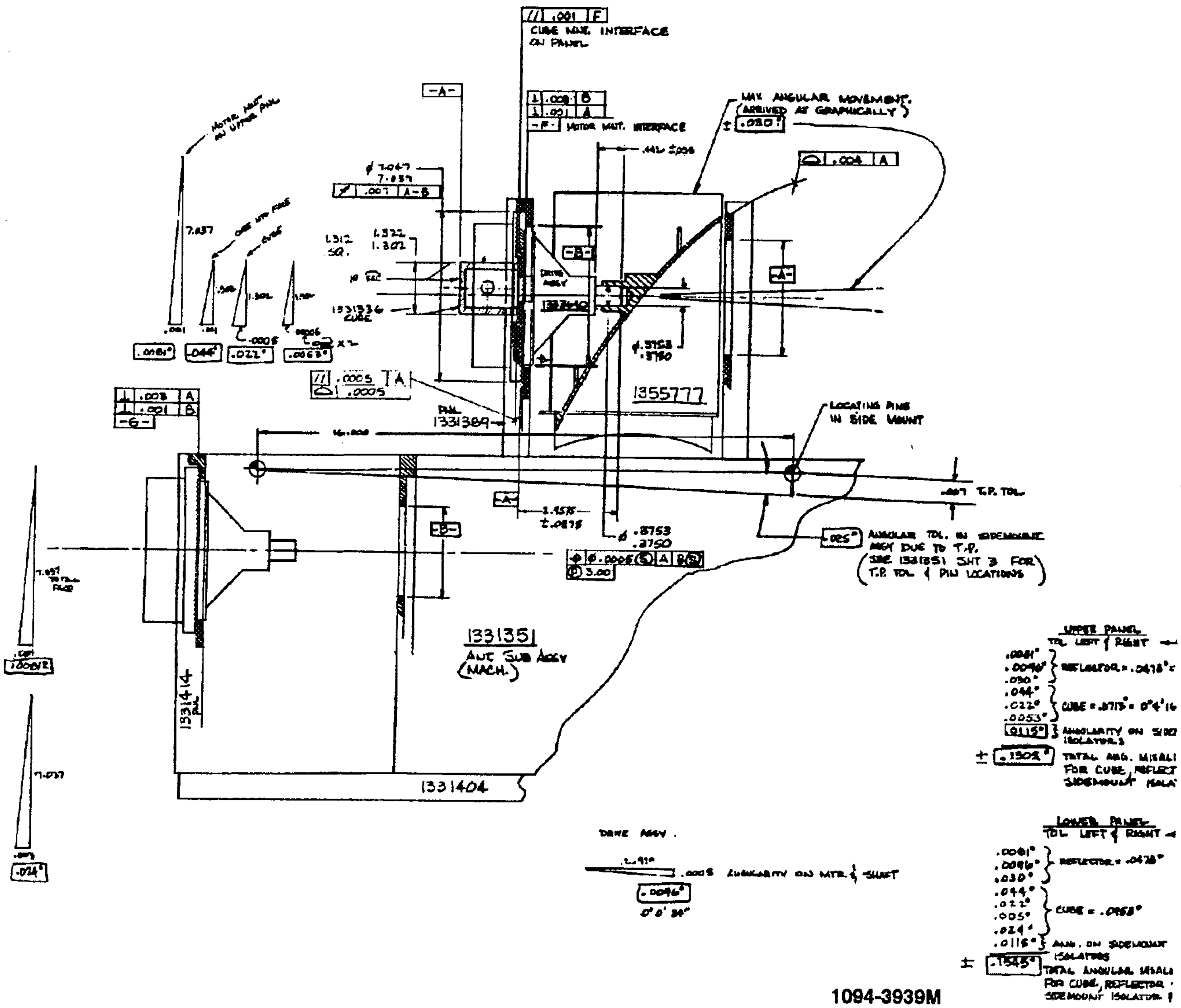

Figure 1 A1 Mechanical Tolerances

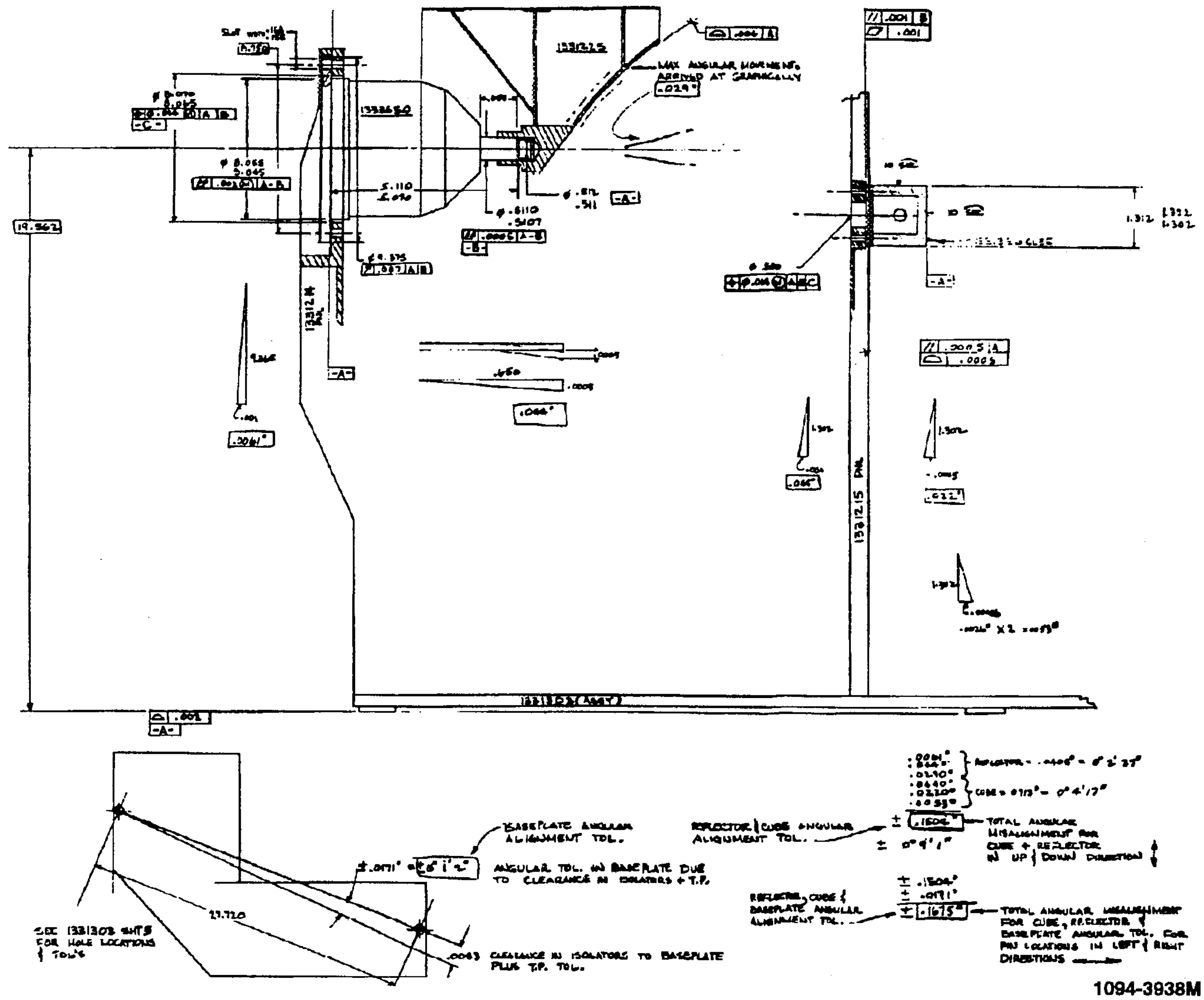

Figure 2 A2 Mechanical Tolerances

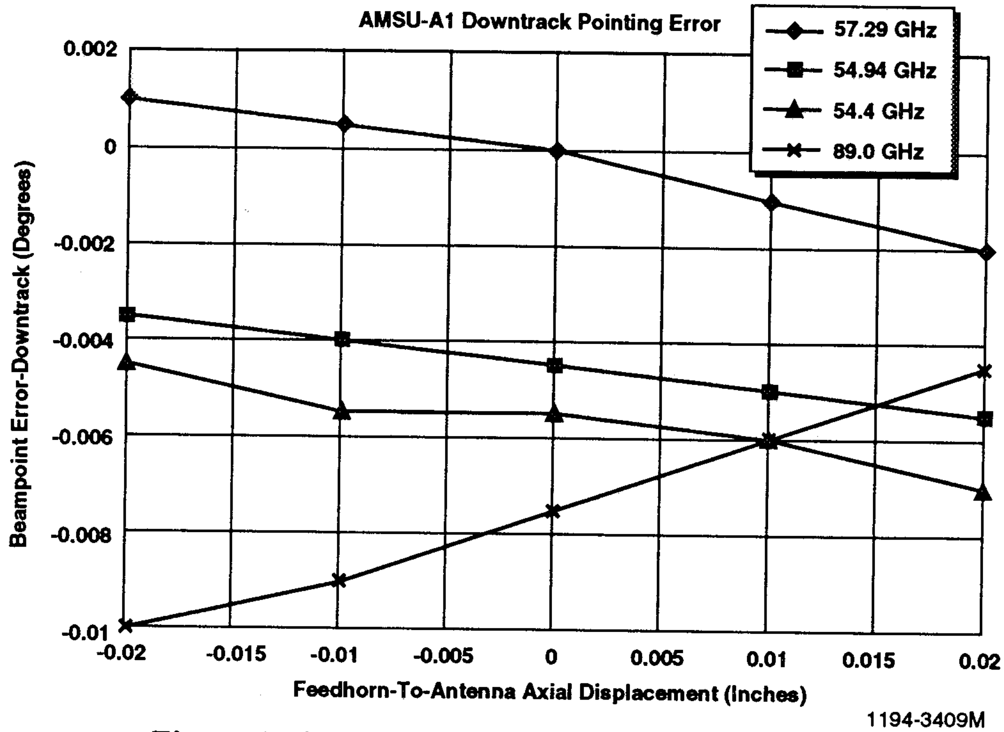

Figure 3 AMSU-A1 Downtrack Pointing Error

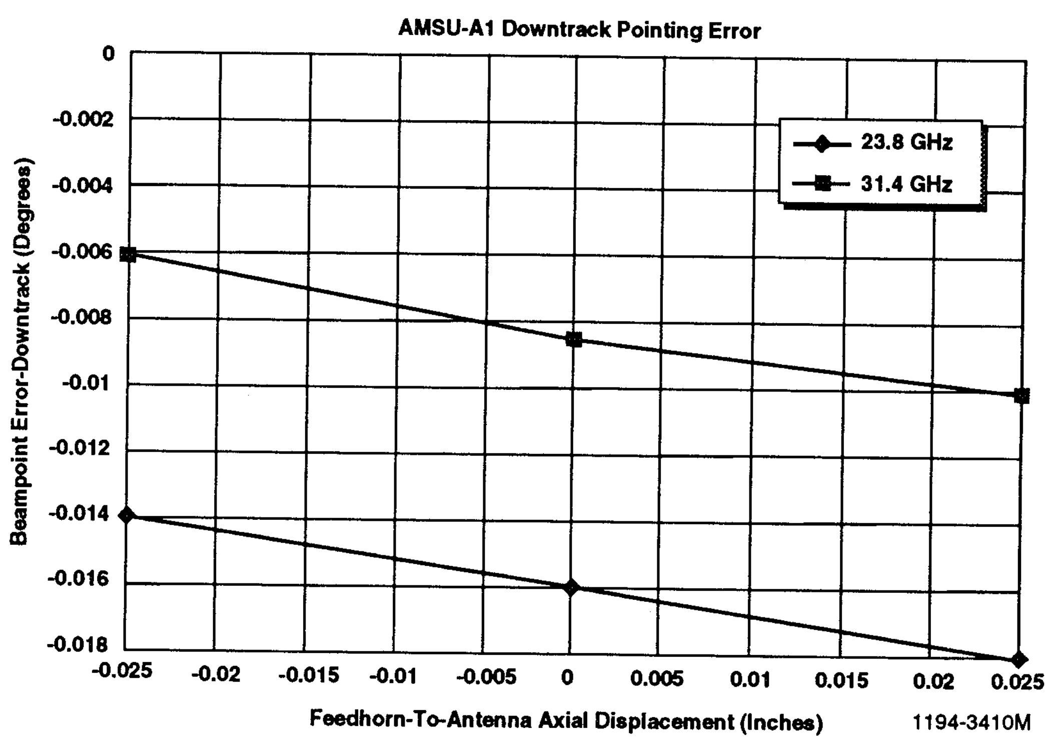

Figure 4 AMSU-A2 Downtrack Pointing Error

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