58-18

41

SWAS SPACECRAFT T/V TEST, UNIQUE IN CHAMBER TESTS SYSTEMS ACTUATION

Jamie L. Dunn
NASA/Goddard Space Flight Center

ABSTRACT

The Sub-Millimeter Wave Astronomy Satellite (SWAS) is the third mission of the Small Explorer (SMEX) Project at Goddard Space Flight Center (GSFC). It is a path finding mission to study the chemical composition of interstellar galactic clouds to help determine the process of star formation. The spacecraft recently completed a month-long thermal vacuum/thermal balance test in the Solar Environmental Simulator, the largest thermal vacuum facility at Goddard. Rather extensive fixturing was required for the test, considering the small size of the spacecraft, and two unusual deployments were completed in order to accomplish the goals of the test. This paper discusses the space simulation testing of the fully integrated SWAS spacecraft and the unique fixturing required.

INTRODUCTION

In addition to the usual objectives of verifying the spacecraft thermal mathematical model and temperature cycling, there were two additional ones which were required for the SWAS thermal vacuum and thermal balance test. While undergoing testing at Ball Aerospace, the instrument's thermal performance did not correlate with the mathematical model that had been developed. Test temperatures differed by as much as 30°C in some instances. There was an unknown quantity of heat flow out of the instrument aperture which had to be characterized at some point during the SWAS spacecraft level test so that a valid thermal model could be created for the instrument. The other main objective during the test was to successfully deploy the solar arrays hot, cold, and while a temperature gradient existed between the inner and outer panels. All of this had to be accomplished within a short period of time due to the project's compressed schedule.

FIXTURE DESIGN

The thermal vacuum and thermal balance test was to be conducted in the Space Environment Simulator (SES), which is 8.23m in diameter and 12.19m in height. The overall length of the extended arrays, approximately 4.11m, necessitated a facility of this size. A total of nine radiator panels ranging in size from $0.065m^2$ to $0.92m^2$ were required, all of which had to be supported by the fixture while providing enough area for the deployment of the solar arrays. In order to accommodate these requirements, a versatile fixture was essential. In an effort to reduce costs and complete the project on time, the fixture was constructed using existing materials from a previous thermal vacuum test. With relatively minor modifications, the aluminum fixture was designed and built in five weeks. The SWAS spacecraft mounted in the completed fixture is shown in Figure 1.

HEATER PANELS

As mentioned above, one of the test objectives was to conduct a solar array deployment while a temperature gradient existed between the inner and outer panels. There was however, nothing in place that could simulate this condition. As a result of the order in which the flight heaters on the rear of the solar arrays were powered, a gradient of this type was impossible. Test heaters could not be applied to the solar cells or the painted rear surface, so the only possibility was to use a radiator panel. In order to avoid losing time by breaking vacuum for reconfiguration, this radiator would have to be movable, so as not to interfere with the subsequent deployment of the solar arrays. For this, two existing heater panels were hinged to the bottom of the SWAS fixture. They were tilted at approximately a 5° angle, enough for them to fall under their own weight when released. A solenoid was mounted above each panel so the pin would enter an existing hole and prevent the panel from falling. Upon activation of this solenoid, the panel would fall away from the spacecraft onto nylon chord strung tightly from supports on the floor.

One heater panel required for the test had a 90° view factor to the body mounted solar array on the spacecraft. It was necessary for this panel to reach a temperature of approximately +125°C in order to simulate the hot test case. Kapton film heaters are normally chosen for test use, but in this case another method of heating had to be used, as the adhesive on the film heaters could break down at +120°C resulting in the heaters becoming detached. Stainless steel strip heaters were chosen, capable of temperatures up to +500°C, and bolted to a 78.74cm x 91.44cm x 0.318cm aluminum panel. Stainless steel braiding was placed between the heaters and the panel to increase conduction. One dozen of these heaters were used and controlled as two separate circuits. Each circuit was wired in parallel, capable of providing 500 watts. This arrangement worked well, with thermal gradients across the panel less than 1°C.


Figure 1: SWAS Spacecraft in Fixture

MICROWAVE ABSORBER

In order to test the instrument under vacuum, a target had to be fabricated that would absorb the emissions from the instrument and reflect as little as possible back to the instrument aperture. The end result of this criteria was a series of 1.27cm thick Plexiglas strips cut at 30° angles that ran parallel to the instrument. The temperature of this "Microwave Absorber" was controlled by a 111.76cm x 81.28cm x 0.635cm aluminum panel that rested on the flat surface of the absorber material. This absorber is shown in Figure 2. It was later conceived that this absorber could not only be used for instrument testing, but could also be used for thermal control. This required a test of the thermal performance of the absorber to determine whether its use as a radiator was feasible.

The absorber panel was loaded into Facility 239, a horizontal loading chamber 2.1m in diameter by 2.4m long. The panel was hung from its support structure as it would be during the spacecraft test, and a cryopanel was placed directly beneath it, simulating the heat input from the instrument aperture. The Plexiglas would need to reach -100°C in order to be used as a target radiator. During the first test run, the aluminum control plate could only reach -115°C, well short of the -180°C temperature necessary. This was a result of poor conduction from the copper coolant lines to the panel. At this temperature, the Plexiglas itself attained a temperature of -50°C. The chamber was


Figure 2: Microwave Absorber

returned to ambient conditions, and aluminum tape was attached to the copper lines and the aluminum plate in order to increase the conductance. This worked for the second run, as the aluminum plate reached the desired temperature of -180°C. Unfortunately, the Plexiglas only reached -75°C.

BLANKET SNATCHER

As a result of the Microwave Absorber panel being unable to achieve -100°C, another method for testing the heat loss from the instrument aperture was needed. The thermal engineer requested a blanket to be placed over the aperture, then removed in order to attain two different thermal boundary conditions. Once again, it was desirable to do this without a chamber break in order to save time. To accomplish this, one end of a nylon cord was tied to the blanket, and the other end to a five pound G-10 fiberglass block. The block rested at an angle on one of the towers that was being used to support the microwave absorber plate. A solenoid held it in place, and once activated, the block would fall, pulling the blanket away from the instrument aperture.

TEST RESULTS

The testing was an overall success. The as-run test profile is shown in Figure 3. Three solar array deployments were completed successfully, one each at -50°C and -5°C, and a third while under a temperature gradient. The temperature gradient achieved was only 9°C, though, which was less than the desired 20°C. This was acceptable, however, as it was the best result that could be achieved given the time allotted. The deployable heater panels worked well, although one of them had to be altered during a chamber break due to thermal expansion. The "blanket snatcher" operated without fault, and the instrument aperture heat loss was characterized by the thermal engineer as being 14 watts. The thermal mathematical predictions for the spacecraft were within 5°C, and a new model was developed for the instrument based on the test results.

Figure 3: SWAS Test Profile